The Federal Plan for Meteorological Services And Supporting Research

FISCAL YEAR 1979

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

U.S. DEPARTMENT OF COMMERCE/National Oceanic and Atmospheric Administration

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FISCAL YEAR 1979

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Preface

Section 304 of Public Law 87-843 requires that, in connection with the budget presentation for each fiscal year, the Congress will be provided with a horizontal budget showing the totality of the programs for meteorology, the specific aspects of the program and funding assigned to each agency, and the estimated goals and financial requirements. The Bureau of the Budget in its Circular A-62 of November 13, 1963, made the Department of Commerce responsible for a systematic and continuing review of basic and specialized meteorological requirements, services, and closely related supporting research, and for the preparation and maintenance of a plan for the efficient use of meteorological services and supporting research. Commerce established the Office of the Federal Coordinator in NOAA to conduct this program. The plan prepared annually as directed by Circular A-62 is also intended to satisfy the requirements of Section 304 of Public Law 87-843. The plan describes the Federal meteorological programs designed to reduce the economic and social impact of natural disasters, promote the Nation's welfare and economy, preserve and enhance the environment, and strengthen the national security.

The principal work of coordinating weather activities and preparing and maintaining the Federal Plan is performed by two interdepartmental committees—the Interdepartmental Committee for Meteorological Services and the Interdepartmental Committee for Applied Meteorological Research. Membership is shown on the inside cover of this Plan. Those committees and their subcommittees make systematic reviews of basic and specialized meteorological requirements, services, and related supporting research. They also prepare specialized plans that supplement these activities. A list of the current specialized plans is summarized in the publications section of this Plan.

Membership for two other activities, under the Federal Coordinator for Meteorological Services and Supporting Research, is also shown on the inside cover of this Plan—the Joint Committee for Space Environment Forecasting and the Interagency Committee for the World Weather Program. The former committee is a recent addition to the organization. The activities of these committees are documented elsewhere and are not included in this Plan.

Fiscal data for the 1978 and 1979 fiscal years are summarized following the introductory section. Next, the basic and specialized meteorological services are each presented from an operational point of view along with the supporting research aimed at improving the individual services.

Richard E. Hallgren, Federal Coordinator
Meteorological Services and Supporting
Research

Contents

Introduction—Changes in Meteorological Programs

Federal meteorological agencies provide a broad range of forecasts and other services to the public and to specialized users, services that contribute to the welfare of the Nation in the broadest sense of the word. Meteorologists, administrators, and the public are alike in taking these services for granted most of the time. The needs of the users of meteorological services and the capabilities of the suppliers change relatively slowly. Thus, change in the meteorological services often seems to proceed at a glacial pace. Change and progress are inseparably (although inaccurately) linked in the minds of most observers, and the net impression is one of a field in which little progress is being made.

In common with other sciences, meteorology progresses in irregular episodes of expansion and consolidation. Although most meteorologists feel that their particular specialty is an exception, there is wide agreement among meteorologists that—insofar as practical forecasting is concerned—we are still on the plateau reached soon after satellites and primitive-equation prognostic methods became integrated into practice. The large-scale synoptic experiments such as GATE and GARP have given atmospheric scientists convincing evidence that the dynamics of weather and climate are fully as complicated as even the most pessimistic theorists had predicted. Rather than showing the way to prompt improvements in forecasting, the evidence gathered during these experiments indicates that improvement will be hard-won.

If operational meteorology cannot ride along on the crest of a fast-breaking advance in theoretical understanding, what steps can we take to assure that our service does not stagnate? We can improve the other links in the chain of service: the means of weather observation, the communications between the observations and the forecasts, as well as the communications between the forecasts and the users of the forecasts. We can improve the means by which our present knowledge of scientific forecasting is applied in practice by improving the capacity and speed of data-handling and processing systems. Perhaps most important of all, we can improve the utility of forecasts by studying how weather information is actually used in industry and commerce, in agriculture, in transportation, and in society in general.

This year's issue of the *Federal Plan* includes a number of programs that represent improvement in services rather than improvements in meteorology as such. These advances will not only result in betterment of the practical benefits derived by the users of meteorological services today, but will also help prepare the foundation for more direct advances in the science of meteorology itself.

1. In the National Weather Service (NWS), the Community Preparedness Program develops plans and teaches communities how to respond to NWS warnings of tornadoes, hurricanes, floods, flash floods, and other natural disasters. The overall objectives are to save lives, reduce the number of injured, and lessen the social and economic impact from these violent storms. Community preparedness meteorologists work with other Federal, State, and local agencies, news media, public safety officials, and school officials on all aspects of planning, preparation, and response regarding natural disasters. Meteorological specialists now provide these services in only 20 States. The planned change in this program is to extend these services to most of the remaining States.

2. Representatives of the Departments of Commerce (NOAA), Defense (USAF), and Transportation (FAA) are working together on a 2-year program to evaluate the feasibility and practicability of using Doppler radar as a network observational and forecasting tool. During the first year (1977), attempts were made to detect and identify in real time those thunderstorms likely to produce tornadoes and damaging wind. Efforts were then made to use this information to improve public warnings at the Oklahoma City Weather Service Forecast Office. A survey of the data collected in 1977 showed increased detection of severe weather and reduced false alarms with Doppler radar. Average tornado lead time was none for NWS warnings without Doppler and 23 minutes for the Doppler advisories given to NWS. Given the large (9.2-m diameter) antenna of the Doppler radar that was used, storm circulations (mesocyclones) can be detected to a range of nearly 350 km. Following the second half of the test in the spring of 1978, the three agencies will apply the test results toward preparing specifications for joint development and procurement of an advanced weather radar that will be cooperatively operated by NOAA, FAA, and USAF in the contiguous United States, with installation in the mid 1980s.

3. The significant impacts of extreme cold during the 1976-77 winter in the eastern United States and of drought conditions during those 2 years in some western States have illustrated the national need for improved knowledge of climate variability. *A United States Climate Program Plan,* published in July 1977 by the Federal Coordinating Council for Science, Engineering, and Technology, provides an official framework for Federal initiatives in climate research and services. The Plan is serving as the basis for more detailed agency climate plans or for fiscal 1979 budgetary initiatives by several agencies, notably the National Aeronautics and Space Administration, the National Science Foundation, and the Departments of Commerce, Defense, Energy, and the Interior. In addition, the Department of Commerce is taking steps to form a Climate Program Office that will function along with and in a manner similar to the Global Atmospheric Research Program Office in NOAA. As an example of climatological service and supporting research improvements for fiscal 1979, NOAA plans to augment support of its Center for Climatic and Environmental Assessment, to carry out diagnostic studies of recent climatic fluctuations and develop long-range prediction techniques.

4. In the Department of Commerce, Automation of Field Operations and Services (AFOS) is underway to enable NOAA to apply modern technology and automation techniques to its day-to-day weather service operations. The goals of this program are to reduce NOAA's response time between detection of natural disasters and issuance of warnings to the public, to improve and extend warning and forecast services, and to reduce the manpower and other costs required to provide these improved weather services. The concept of automated field office operations makes use of minicomputers and TV display equipment at field sites, interconnected and linked by high-speed transmission lines to the National Meteorological Center at Suitland, Md.

5. NOAA/NWS is the source of most weather data and information for other agencies having significant weather interests. In turn, these other agencies have significant amounts of data of interest to NOAA. Exploratory designs have been developed for specific interfaces between AFOS and other systems. The general concept of the interfaces is as follows:

a. For national integrated agency systems, a single interface is planned.

b. For regionally integrated agency systems, the interface will be at the center of region activity.

c. More fractionated agency interfaces will be defined by primary functional interest (e.g., River Forecast Centers for hydrologic interests) or by the degree of conglomeration that may exist among the multiagency interests.

When NWS facilities become operational on the AFOS network they will no longer interface directly with FAA's Weather Message Switching Center in Kansas City, Mo. There will be one interface point called the Gateway at the System Monitoring and Coordination Center at Suitland, Md., for transferring data into and out of the AFOS system.

An interface is planned between AFOS and the Air Force Global Weather Central (AFGWC) to maintain backup capability in accordance with the Federal Plan for Cooperative Backup Among Operational Processing Centers. AFGWC will provide backup products to AFOS when the National Meteorological Center or the National Severe Storms Forecast Center are unable to transmit.

6. Subject to funding approval, the Air Force plans to modernize the base weather station's functions in a manner similar to the automated weather support systems planned or being used by the Departments of Commerce and Transportation. The Automated Weather Distribution System (AWDS) will use the latest state-of-the-art data processing, communications, and display technologies. An automated observing subsystem will receive, display, and transmit—long line and locally—surface weather observations. The data handling subsystem will eliminate most of the labor-intensive tasks associated with forecasting. AWDS will interface through an automated dissemination/display system with local air traffic control facilities and AFGWC. It will be compatible with AFOS and the Navy's newly developed Naval Environmental Display Stations (NEDS). Initial deployment of NEDS-1 units commenced in fiscal 1977. These units are concentrated mainly at the Fleet Weather Centrals. However, initial deployment of the units (NEDS-1A) to be used at most Navy environmental support activities will not commence until late in fiscal 1979. Interface between NEDS and AFOS is planned so that selected NOAA/NESS products will be available for Navy use.

7. NWS and FAA are collaborating to establish facilities and procedures that will guarantee availability of weather information and advice to air traffic controllers and pilots on a real-time basis so that correct and timely flight decisions can be made. Experimental weather units at the Kansas City and New York Air Route Traffic Control Centers (ARTCC) have helped prove the feasibility of the support concepts planned by NWS, FAA, and the Air Force Air Weather Service. Weather facilities manned by professional meteorologists are being established in 13 ARTCCs. Using AFOS, complemented by current radar and satellite data and pilot reports, the forecaster will provide advice on the existing and forecast weather as it affects aviation operations and safety in the Center's area of responsibility.

8. Concern has developed within FAA regarding the future of the present Flight Service Station system. This concern was prompted by:

- High cost of operating the present, predominantly manual system;
- Higher costs of the system if expanded to satisfy the future demand for flight services;
- Reduced safety to be expected from a lesser expansion of system capacity; and
- Growing need to improve the overall availability and quality of services being provided to the general aviation community.

In response to these considerations, FAA has developed a Flight Service Station Automation Program Plan, designed to meet the projected long-term demand for flight services without proportional increases in staff and operating costs. The plan proposes extensive use of automation and the concept of self-briefing whereby users can access the system directly to obtain a weather briefing or file a flight plan.

The program to automate FAA's Flight Service Stations will provide a national computer-based Flight Service Information System, including an interface with AFOS, either directly or through the Weather Message Switching Center. The Flight Service Station specialists will have direct access to this data base, enabling them to improve the timeliness and quality of briefings and flight plan handling. Pilots will also have direct access to the data base and eventually will be able to satisfy 70 percent of their weather needs without the assistance of a specialist. Thus, automation will help to satisfy the growing demand for service without an increase in system work force.

9. The wide variations that have characterized the world's agricultural production in the past 5 years, arising in large part from some major fluctuations in weather patterns, have focused increased attention on the role of weather and climate in determining the production of food and fiber.

Primary weather and climate responsibilities of the U.S. Department of Agriculture (USDA) include assessing the impact of weather on all aspects of agriculture, forestry, and related natural resources, developing effective management techniques incorporating weather factors, and disseminating weather-related management information to decision makers.

The mission and programs of individual USDA agencies include both research and service activities. These activities are both independent (e.g., support to USDA research projects and policy decisions) and joint (e.g., forecasts, warnings, and advisories in cooperation with the Department of Commerce and cooperative research activities with State Experiment Stations and academic institutions).

Weather-related activities of USDA are currently under review, and many programs are being considered for

expansion. The following selected activities are examples of new directions in research and services:

- Intensified studies of soil moisture,
- Cooperative program (with NOAA) to provide local weather data needed by farmers for day-to-day decision making in pesticide use, irrigation, and production practices,
- Irrigation scheduling,
- Long-term climatic trends and variability,
- Broadened Federal-State cooperative regional research,
- Applications of remote sensing to agriculture, and
- Response of crops to changing climatic conditions

Fiscal Summary

The following tables summarize fiscal information concerning meteorological expenditures of the Federal Government for meteorological services and supporting research for fiscal 1978 and fiscal 1979. The basis for increase or decrease in expenditures is presented for significant changes. The fiscal information is presented by agency in table 1, showing fiscal 1978 data, planned agency expenditures during fiscal 1979, and the net changes. Table 2 summarizes the distribution of dollars by basic and specialized meteorological services.

In fiscal 1979, agencies are requesting $649,488,000 for operational programs. This represents a net increase of $27,552,000 over fiscal 1978. The total operational program net increases being requested by the Department of Commerce are $18,121,000. This consists of increases totaling $12,050,000; an adjustment to the base funding for 1978 of $9,229,000 to allow for unavoidable increased costs of ongoing activities; and an offsetting reduction of $3,158,000 directed by the Office of Management and Budget under the Zero Base Budgeting concept that includes the closing of 19 NWS Offices. Major increase items include $2,550,000 to procure radar data processing equipment for NWS radars; $2,108,000 to upgrade and automate the existing upper air tracking system; $1,000,000 to complete the Community Preparedness Program for most of the remaining States; a net $2,543,000 increase in the meteorological satellite program; and $1,400,000 to improve and modernize climatic services.

In the Department of Defense, the fiscal 1979 net increase for operational programs is $6,784,000. Of this amount the Air

Table 1—Federal Plan for Meteorological Operations and Supporting Research, by agency
(Thousands of dollars)

Agency	Operations			Supporting research			Total		
	FY78	FY79	net difference	FY78	FY79	net difference	FY78	FY79	net difference
Agriculture	370	1,107	+737	2,544	2,713	+169	2,914	3,820	+906
Commerce	283,656	301,777	+18,121	16,434	17,889	+1,455	300,090	319,666	+19,576
Defense	262,602	269,386	+6,784	31,351	40,441	+9,090	293,953	309,827	+15,874
Energy	2,612	2,758	+146	194	212	+18	2,806	2,970	164
EPA	500	500	+0	6,450	6,450	+0	6,950	6,950	+0
NASA	1,483	2,011	+528	21,538	32,630	+11,092	23,021	34,641	+11,620
Transportation:									
Coast Guard	2,878	3,230	+352				2,878	3,230	+352
FAA	67,835*	68,719*	+884	11,733	13,627	+1,894	79,568	82,346	+2,778
Total	621,936	649,488	+27,552	90,244	113,962	+23,718	712,180	763,450	+51,270

**Incomplete. See discussion of FAA program in Fiscal Summary.*

Table 2—Federal Plan for Meteorological Operations and Supporting Research, by service
(Thousands of dollars)

Service	Operations			Supporting research			Total		
	FY78	FY79	net difference	FY78	FY79	net difference	FY78	FY79	net difference
Basic	308,238	324,864	+16,626	37,332	49,879	+12,547	345,570	374,743	+29,173
Aviation	217,521*	223,591*	+6,070	13,820	16,280	+2,460	231,341	239,871	+8,530
Marine	12,756	13,922	+1,166	3,085	3,781	+696	15,841	17,703	+1,862
Agriculture & Forestry	4,736	5,821	+1,085	2,584	2,753	+169	7,320	8,574	+1,254
General Military	48,415	47,392	-1,023	26,779	34,607	+7,828	75,194	81,999	+6,805
Other	30,270	33,898	+3,628	6,644	6,662	+18	36,914	40,560	+3,646
Total	621,936	649,488	+27,552	90,244	113,962	+23,718	712,180	763,450	+51,270

**Incomplete. See discussion of FAA program in Fiscal Summary.*

Force's net increase of $4.7 million is principally for training, equipment, communications, and reconnaissance, and the Navy's $2 million is for automation and training.

Under the Department of Transportation, a net increase of $884,000 is planned by the Federal Aviation Administration (FAA). Significant changes include an increase of $3,600,000 for procurement of meteorological equipment and anticipated growth in pilot briefings offset by a $3,800,000 decrease for reductions in teletypewriter usage as AFOS is installed and for canceling voice broadcasts of aviation weather where automatic recording and transmitting equipment is installed. Costs for operations in FAA for fiscal 1978 and 1979 do not reflect costs of implementing Center Weather Service Units in 13 Air Route Traffic Control Centers that began in April 1978. For details, see section on Aviation Meteorological Service.

In fiscal 1979 the supporting research programs for all Federal agencies will cost $113,962,000, representing a net increase of $23,718,000 over 1978. The National Aeronautics and Space Administration (NASA) increase of $11,092,000 includes $8,000,000 for the Earth Radiation Budget Sensor System, and $2,000,000 for the Atmospheric Cloud Physics Laboratory to be on the Space Shuttle.

The Department of Defense plans an increase of $9,090,000. The most significant items include $6,000,000 for the Army's Field Artillery Meteorological Acquisition System and $2,000,000 for environmental prediction and remote sensing in the Navy. Only $3.3 million of the FAMAS program is funded currently.

In the Department of Transportation, FAA's projected net increase of $1,894,000 includes major items of $1,200,000 for the Flight Service Station automation program, $800,000 for development work to modify air traffic control radars to detect weather, $700,000 for automatic weather observation systems, and an offsetting decrease of $1,000,000 due to completed contracts and studies in the wind shear program. The Department of Commerce increase of $1,455,000 represents modest increases distributed over several programs.

In table 2, the major increases planned by the Departments of Commerce and Defense for operational programs are reflected in the large net differences shown for Basic, Aviation, and Other Specialized Meteorological Services. In supporting research, all of NASA's $11 million increase is in support of Basic Meteorological Services, FAA's $1.9 million increase is for Aviation, and the bulk of Defense's $9 million is in support of General Military Meteorological Service.

Table 3 shows the amount of funds transferred between Federal agencies in fiscal 1978 for the purchase of meteorological services and supporting research. The major items include $4.1 million (DOC to DOD) for operational weather reconnaissance, $51.9 million (DOC to NASA) for the meteorological satellite program, $1.3 million (DOD to DOC) for meteorological data and climatological services, $1.6 million (DOE to DOC) for services and product improvement in support of the Nation's nuclear testing program, $2.1 million (EPA to DOC) for the supporting research program at Research Triangle Institute, N.C., and $1.3 million (NASA to DOC) for services supporting space operations.

Table 4 lists agency manpower engaged in weather operations by function. The fiscal 1979 fiscal data contained in this Plan are reflected in the President's budget and should be used for planning purposes only. The scheduling and implementation of these programs after 1979 are subject to additional analysis and change.

Table 3—Interagency fund transfers for Meteorological Operations and Supporting Research
(thousands of dollars)

Agency		Funds	
Transferred from	Transferred to	Fiscal year 1978 Operations	Research
DOC	DOD	4,103	
DOC	NASA	51,902	
DOD	DOC	1,349	125
DOE	DOC	1,612	144
DOT	DOC	638	300
DOT	DOD		60
DOT	DOI		300
EPA	DOC	425	2,175
NASA	DOC	1,321	250
NASA	DOD	5	

Table 4—Agency Manpower Engaged in Weather Operations, by Function

Personnel	Observations		Analyses & forecasts		Communications		Dissemination to users		General agency supp.		Total	
Agency	FY78	FY79	FY78	FY79	FY78	FY79	FY78	FY79	FY78	FY79	FY78	FY79
Commerce	1,446	1,419	1,749	1,744	138	138	1,019	1,018	1,343	1,329	5,695	5,647
(1)	40	40	204	204	1	1	-	-	42	42	287	287
Defense	2,526	2,519	996	996	651	631	2,026	2,029	1,404	1,339	7,603	7,514
(2)	321	321	651	660	238	240	283	283	1,061	1,170	2,554	2,674
(3)	2	2	6	6	2	2	3	3	3	3	16	16
Transportation												
Coast Guard												
(2)	160	158	-	-	32	32	9	9	13	13	214	212
FAA												
(2)	318	330	-	-	692	664	772	830	460	474	2,242	2,298
Total	4,813	4,789	3,606	3,610	1,754	1,708	4,112	4,172	4,326	4,369	18,611	18,648

(1) Personnel funded by other agencies. (2) Man-years. (3) Man-years funded by other agencies.

Meteorological Services

Introduction

Circular A-62, mentioned in the Preface to this plan, divides meteorological services into two types, basic and specialized. Basic meteorological service, in which the Department of Commerce plays a central role, is designed to meet public needs and the common needs of other agencies, and constitutes the foundation for disaster warnings and the specialized services. The specialized meteorological services are generally derived from the output of the basic meteorological service and include the facilities, products, and distribution mechanisms for servicing the needs of specialized users such as those involved in aviation, marine, agriculture and forestry, and general military operations.

Basic Meteorological Service

Description

The Basic Meteorological Service is used by the general public, many segments of private industry, and departments and agencies of the Federal government. The effectiveness of the Basic Meteorological Service depends upon the cooperative efforts of several Federal agencies as well as the member nations of the World Meteorological Organization.

The general functions involved in providing the service include:

- Observing current weather conditions,
- Communicating weather data and information,
- Preparing analyses and forecasts,
- Issuing and disseminating warnings and forecasts, and
- Archiving weather information for ready retrieval

The first of these functions is composed of four fundamental weather observing programs—surface, upper air (includes aerial weather reconnaissance), radar, and meteorological satellites. Our national programs are complemented by other countries' observation programs. Taken as a whole they represent our capability for detecting and tracking potentially hazardous weather as well as providing data for basic analysis and forecast services.

Table 5 shows the number of locations where each of the Federal agencies makes surface and upper air observations, together with the number of aircraft equipped to perform weather reconnaissance.

Table 5—Locations by Observation Function, Fiscal Years 1978-79

Observation Function	Agency	No. FY78	No. FY79
Surface (land)	Commerce[1]	589	574
	Defense (U.S.)	149	149
	Defense (overseas)	81	81
	Energy	10	10
	Transportation (FAA)	367	367
	Transportation (Coast Guard)	165	160
	NASA	3	3
Surface (marine)	Commerce (merchant ships cooperative program)	2,119	2,000
	Transportation (Coast Guard ships)	82	81
	Defense (ships with meteorological personnel)	30	30
	NOAA ships	30	30
Upper air (rocket)	NASA	1	1
	Defense	13	13
	Energy[2]	2	2
Upper air (balloon)	Commerce (U.S.)	96	96
	Commerce (overseas)	24	24
	Defense (fixed) (U.S.)	7	7
	Defense (fixed) (overseas)	16	16
	Defense (ship)	31	31
	Defense (mobile)	37	37
	Energy[2]	2	2
	NASA (U.S.)	3	3
	Transportation/Coast Guard[3]	20	19
Weather radar	Commerce (U.S.)	115	118
	Defense (U.S.)	88	88
	Defense (overseas)	26	26
	NASA (U.S.)	1	1
Weather reconnaisance	Defense (No. of aircraft)[4]	20	20

[1] Cooperative stations operated by Departments of Agriculture, Interior, and Transportation, other public and private agencies, and those manned by volunteers are not included. Also excluded are about 300 Supplementary Aviation Weather Reporting Stations and foreign cooperative stations.
[2] Inactive, but available for use.
[3] Balloon support facilities inactive, but available for use.
[4] 7WC-130s operated by AF Reserve.

OBSERVING CURRENT WEATHER CONDITIONS

Surface Observations

Surface observations are taken by the Departments of Commerce, Defense, Transportation, and Energy, and National Aeronautics and Space Administration (NASA) at about 1,400 land locations. These observations support basic analysis and forecasting functions and the specialized services. Observations are also taken for the Department of Commerce by citizen volunteers and by employees of the Departments of Agriculture and Interior at some 13,000 cooperative stations. The volunteer stations support climatological and specialized observational needs, and the stations of the Departments of Agriculture and Interior support agriculture and forestry needs.

Surface observations are taken at sea by Department of Defense ships, and vessels of the merchant fleet provide cooperative observations in a program operated by the Department of Commerce. The Department of Transportation's Coast Guard operates ship as well as shore and island stations.

Automatic weather stations are increasingly used for essential observations as an adjunct to manned operations and at unmanned or inaccessible locations on land and sea. These stations are in key areas to obtain weather observations for use in preparing forecasts and warnings. There are now 72 automatic stations that measure wind, temperature, dewpoint, pressure, and amount of liquid precipitation, plus 31 stations with limited sensor capability (e.g., wind data only). In addition, 18 automated buoys are positioned off the Pacific northwest, the Gulf of Mexico, and off the mid-Atlantic coast. One of the buoys in the Atlantic is the replacement for Ocean Weather Station HOTEL and is at latitude 39° North, longitude 70° West.

NWS successfully installed two automatic weather stations, one at Summit, Alaska, and one at Wendover, Utah, with improved sensing equipment to specify clouds and visibility. They are routinely providing completely automatic observations including cloud and visibility information for operational purposes. NWS plans to extend this type of station to other locations to replace manned operations that are being curtailed or closed.

Upper Air Observations

Data from the upper air observing network provide the basic input to numerical analysis and forecasting. The Department of Commerce operates land facilities in the United States to make upper air observations (balloon) and supports meteorological programs for observations on islands of the U.S. Trust Territory in the Pacific Ocean. The Department of Defense participates both at U.S. and overseas areas through operations of its land and ship facilities. While there is a regular network of upper air stations both in the United States and selected overseas areas, it is not economically feasible to have complete coverage of the adjacent oceans and other data-sparse areas. Supplemental upper air data over these areas are provided by Department of Defense weather reconnaissance flights and by in-flight pilot reports from commercial, general, and military aviation. Also, NASA and the Department of Defense use rocketsondes to obtain temperature and wind measurements at altitudes from 30 to 100 km at 14 locations in North and Central America and the surrounding ocean areas.

The Department of Defense performs tropical cyclone aerial reconnaissance in the Western Pacific in response to military and civilian requirements and in the Eastern Pacific, Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico in accordance with the provisions of the *National Hurricane Operations Plan* (revised annually). Sufficient resources are available to provide twenty-four hour coverage of a storm, with the maximum coverage provided when the cyclones threaten the U.S. coast, Puerto Rico, Virgin Islands or Department of Defense resources. In addition, extratropical winter storm reconnaissance is flown in the western Atlantic in accordance with the provisions of the *National East Coast Winter Storms Operations Plan* (revised annually). In October 1976 NOAA began reimbursing the Department of Defense for all reconnaissance flown in support of these two operations plans.

Radar Observations

Radar is a principal source of weather information for making the short-term warnings of severe weather that contribute heavily to saving lives and property in many areas of the Nation. These radar observations provide:

- The best methods now available for the remote identification and tracking of severe thunderstorms, squall lines, tornadoes, and other destructive storms,
- A means for locating, tracking, and estimating the intensity of tropical cyclones as they approach the coast,
- The information upon which estimates of precipitation rates and amounts can be based for use in flash-flood warnings and river stage and flow predictions, and
- A means for detecting potentially hazardous turbulence in convective storms.

The Basic Weather Radar Network includes 56 Department of Commerce and 4 Department of Defense radars plus 22 Federal Aviation Administration (FAA) Air Traffic Control radars used to provide data from the western U.S. mountainous areas. Basic network radars with long-range detection capability are manned around the clock to provide continuous severe storm surveillance. Local warning radars complement this network at 135 locations to detect and track severe local storms in susceptible areas not covered adequately by the basic network. Local warning radar data serve as the basis for detailed short-period warnings and forecasts.

The FAA radars used as part of the basic network in the mountainous regions of the West are being modified to improve aircraft control. This modification reduces the amount of weather data transmitted into the ARTC Centers for processing by NOAA radar specialists. To ensure the availability of radar observations needed for detecting and tracking severe weather over the large region, equipment will be procured to obtain the weather data directly at ARTCC radar antenna sites for transmission to NOAA/NWS radar specialists in the ARTC Centers and NWS facilities.

Meteorological Satellites

The fourth Basic Meteorological Service observing program consists of polar-orbiting and geostationary satellites. Operational systems include those operated by the Department of Commerce and the Department of Defense.

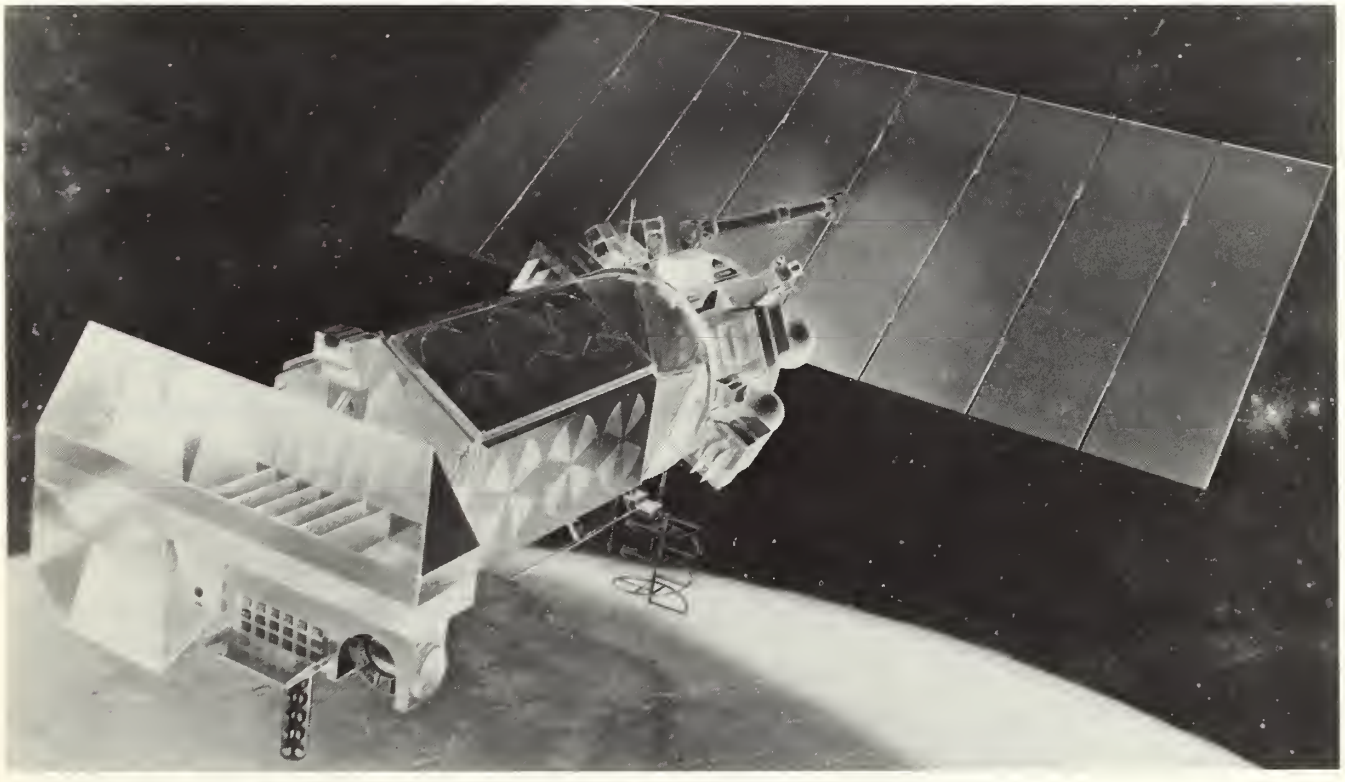
The Department of Commerce, through NOAA National Environmental Satellite Service (NESS), is the agency

responsible for a national operational environmental satellite system. The Department is charged with operating and improving the system to meet the common requirements of all Federal agencies. The objectives of the operational system are:

- Provide global imagery of the Earth and its environment on a regular basis, day and night, including direct readout to local ground stations within radio range of the satellite,
- Obtain quantitative environmental data on a global basis, such as temperature, moisture, winds, radiation flux, and solar energetic particle flux, for use in numerical analysis and prediction programs,
- Obtain near-continuous observations of the Earth and its environment, collect data from remote observing platforms (including automatic weather stations, balloons, aircraft, ships, buoys, and river and tidal stations), and broadcast weather data to remote locations, and
- Contribute to improved monitoring and prediction of the atmospheric, oceanic, and space environments by developing applications of satellite information.

The operational system includes polar-orbiting and geostationary satellite programs directed toward satisfying the above objectives. The system also includes command and data acquisition stations; a satellite operational control center through which the satellites are controlled and data acquired; facilities for processing and analyzing satellite data and products; and laboratories for satellite sensor experiments and developing applications of satellite data. Within the conterminous United States, some direct readout and processed data and products are distributed to users over NWS facsimile networks. Also, Satellite Field Services Stations (SFSSs) have been established to analyze, interpret, and distribute processed geostationary satellite products to regional NWS offices and other Federal agencies. The products are also made available to private activities at their own cost. SFSSs are located in Washington, D.C., Miami, Kansas City, Honolulu, San Francisco, and Anchorage. The Anchorage, Alaska SFSS distributes mainly data from the polar-orbiting satellites and limited data from the geostationary system.

The current polar-orbiting satellite system, the Improved TIROS Operational Satellite (ITOS), became operational in December 1970. The ITOS satellites obtain measurements of the vertical temperature structure and total water vapor content of the atmosphere in cloud-free areas using the Vertical Temperature Profile Radiometer (VTPR). The temperature soundings produced are distributed nationally and internationally for use in programs of quantitative numerical analysis and prediction. Unprocessed VTPR data are broadcast continuously from the satellite for local reception. This is known as the direct sounder transmission service and is available worldwide to any properly equipped ground station. The ITOS system also provides high resolution (1 km) observations of the Earth's cloud cover, cloud top temperatures, and, in cloud-free areas, sea-surface temperatures using the Very High Resolution Radiometer. Global day and night cloud imagery with resolutions of 4 and 8 km are obtained by using the Scanning Radiometer (SR). Worldwide readout of local area SR imagery is available through the Automatic Picture Transmission. Also, global SR infrared measurements are processed as large-scale analyses of



Artist conception of NOAA's third generation operational polar-orbiting satellite. The NASA prototype, planned for launch in mid-1978, is known as TIROS N. Subsequent satellites will be called NOAA.

sea-surface temperature. The ITOS system Solar Proton Monitor obtains data on the energetic particle flux in polar areas.

Satellites in the ITOS system are called NOAA and numbered consecutively following launch and successful insertion into orbit. The current operational satellite is NOAA 5. NOAA 4 is in orbit on standby and is available as a limited backup to NOAA 5 should the need arise. The ITOS system (the second generation of polar-orbiting satellites) will be succeeded during 1978 by a third generation of operational satellites. The NASA-funded prototype known as TIROS N, planned for launch in mid-1978, will be followed in 4 to 6 months by the first of seven NOAA-funded satellites. These will retain the NOAA name and will be numbered consecutively beginning with the number immediately following that last used in the ITOS program. The third generation system is expected to be fully operational by the end of 1978.

The TIROS N system will focus on increasing the accuracy of weather forecasting by providing quantitative data required by improved numerical models. Table 6 compares the ITOS and TIROS N series features.

The geostationary satellite program began during the latter half of the 1960s as an operational experiment in which the imaging capability and broadcast system (WEFAX) of the NASA Applications Technology Satellites 1 and 3 were used. The program became an operational reality following the launch of NASA's Synchronous Meteorological Satellites (SMS) 1 and 2 in 1974 and 1975, respectively. NASA released to NESS both SMS 1 and 2 for operational control and use following the initial checkout period. These satellites were the prototypes for NOAA's Geostationary Operational Environmental Satellite (GOES). GOES 1 was launched October 16, 1975, and GOES 2 was launched June 16, 1977. The current operational system consists of GOES 2 and SMS 2. GOES 2 replaced GOES 1 as the eastern operational satellite on August 15, 1977. GOES 1 and SMS 1 remain in orbit at longitude 105° West and serve as backups for the other two satellites. It is planned to launch GOES C during the last half of FY 1978.

The two operational satellites in the GOES system are over the Equator near longitude 75° West and longitude 135° West. These satellites provide repetitive viewing of the development and movement of destructive weather systems,

Table 6—Comparison of ITOS and TIROS N series features

	ITOS	TIROS N Series
Atmospheric soundings	Restricted by clouds or other moisture and ability to correct for their presence.	Additional channels and improved geometry will increase probability of obtaining soundings from the infrared measurements. Also, the microwave sounder provides a capability, within limits to sound through clouds.
	Accurate to 3°C root mean square (rms)	Accurate to 1.5° rms
	Temperature profiles to 30 km	Temperature profiles to 48 km. The Stratospheric Sounding Unit will be provided by the United Kingdom.
	Provides total water vapor content in lower 5 km.	Provides water vapor content in three layers in the lower 10 km of the atmosphere.
High Resolution Radiometry	Sea surface temperature accurate to 2-3°C rms	Accurate to 1.5°C absolute, and 0.5°C relative on a 10 km grid at least once each day, and to 1.0°C absolute on a 100 km grid once per day.
	Scanning Radiometer—two channels (visible and infrared); resolution 4 km (visible) and 8 km (infrared). Very High Resolution Radiometer (VHRR)—two channels (visible and infrared) resolution 1 km both channels	Advanced VHRR—four channels in early spacecraft, five channels in later spacecraft. Resolution 1 km and 4 km depending on function. More accurate sea surface temperatures; better differentiation of clouds, snow and ice, and liquid water.
Data Collection	Not available	Provides for receipt, processing and retransmission of data from fixed and moving platforms, and locates the latter accurate to 5-8 km rms. Spacecraft system will be provided by France.
Space Monitoring	Measures energetic particle flux along local vertical and normal to spacecraft.	Monitors solar proton and electron flux density and total energy distribution in the near-earth space environment.
Design lifetime/ growth potential	12-15 months/none	24 months/25% growth potential

such as thunderstorms, hurricanes, and major mid-latitude storms over much of North and South America and adjacent oceans. The principal instrument is the Visible and Infrared Spin Scan Radiometer (VISSR). The VISSR provides near-continuous cloud viewing with resolutions of 1, 2, 4, and 8 km in the visible wave lengths and 8 km in the infrared wavelength. Full Earth disc pictures are available at 30-minute intervals throughout the day and night; partial disc pictures can be obtained at more frequent intervals to meet special requirements such as viewing development and movement of severe storms. The GOES Data Collection System is used to collect and relay environmental data observed by remotely located sensing platforms, such as automatic weather stations, buoys, and river and tide gages. These satellites also broadcast environmental data to remote locations using the WEFAX system, and collect data for warnings of solar activity, using the Space Environment Monitor. In the contiguous United States and Hawaii, the Department of Defense uses drops from the GOES dissemination systems to the maximum extent possible.

The Defense Meteorological Satellite Program (DMSP) is an operational meteorological satellite system managed by the U.S. Air Force under the Department of Defense. The Air Force furnishes DMSP data and all specifications for their use to Department of Defense meteorologists, NOAA/NESS, and NOAA/EDS. NOAA/NESS is responsible for further dissemination of DMSP data to other U.S. government agencies and to the U.S. and international scientific communities. NOAA/EDS is responsible for archiving DMSP data. To help reduce costs, DMSP and TIROS N will have common spacecraft except for on-board sensors and certain specialized equipment. Also, TIROS N will use surplus Department of Defense boosters and Air Force launch crews. Details on DMSP are covered in the section titled General Military Meteorological Service. Table 7 shows operational program costs for weather satellites in the Department of Commerce and Defense.

COMMUNICATING WEATHER DATA AND INFORMATION

The utility of the Basic Meteorological Service depends upon an effective communications network. Weather observations are collected and distributed nationally by communications systems operated by the Department of Defense, FAA, and NOAA. Exchange of data between nations is accomplished by international and Department of Defense weather communications circuits linking the United States with overseas data sources. Using these observations, centers prepare analyses and predictions for transmittal to forecast offices, local weather offices, and other government and authorized private users over Departments of Commerce and Defense facsimile networks and teletypewriter circuits. High-quality satellite photos are distributed over other circuits to forecast offices and other governmental and authorized private users.

Appendix A gives the major meteorological communications systems in use.

PREPARING ANALYSES AND FORECASTS

Basic analysis and forecast products for Federal agencies and industrial and commercial users are provided from NOAA's three NWS centers—the National Meteorological Center at Camp Springs, Md., the National Hurricane Center at Miami, Fla., and the National Severe Storms Forecast Center at Kansas City, Mo.

The National Meteorological Center (NMC), provides basic weather analyses and forecasts for the Northern Hemisphere and portions of the Southern Hemisphere. During a typical day, NMC processes more than 40,000 surface observations, 2,800 aircraft reports, 2,000 ship reports, 1,500 upper air soundings, several hundred vertical soundings derived from satellite data, and global cloud-cover data from weather satellites. NMC products include more than 400 charts for facsimile transmission and 200 messages for teletypewriter distribution daily to its users primarily in North America, but including others in overseas areas as well. Emergency backup for NMC is provided by the Air Force Global Weather Central in Nebraska and by the Navy Fleet Numerical Weather Central in California in accordance with the *Federal Plans for Cooperative Backup Among Operational Processing Centers,* December 1976, FCM 76-4.

The NMC operation is designed to produce forecast guidance products on a scheduled basis. Computer support for processing both NMC and National Environmental Satellite Service products is currently satisfied by three advanced computers on a shared basis.

The National Hurricane Center (NHC) provides basic forecasts and warnings of hurricanes in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico for all Federal agencies and user groups.

The National Severe Storms Forecast Center issues convective outlooks, and severe thunderstorm and tornado watches, in support of civil needs. Severe weather watches are issued on an as needed basis and indicate areas where severe

Table 7—Agency Operational Weather Satellite Program Costs by Function
(Thousands of dollars)

	Spacecraft & Launching		Command and data acquisition		Data processing		Technical Management & Support		Total	
	FY78	FY79	FY78	FY79	FY78	FY79	FY78	FY79	FY78	FY79
Commerce	53,730	54,871	8,837	9,831	10,947	11,240	11,405*	12,144*	84,919	88,086
Defense										
Air Force	47,675	44,940	10,377	13,216	4,993	3,937	12,900	11,600	75,945	73,693
Navy	—	—	4,554	4,899	2,156	662	200	200	6,910	5,761
Total	101,405	99,811	23,768	27,946	18,096	15,839	24,505	23,944	167,774	167,540

**Includes SFSS and local display.*

thunderstorms or tornadoes are possible. Convective outlooks in graphical and written form discuss possibilities of both general and severe thunderstorms. These outlooks are issued twice daily, except for the period February-August when they are issued three times per day. Emergency backup for the National Severe Storms Forecast Center is provided by Air Force Global Weather Central as outlined in the *National Severe Local Storms Operations Plan,* January 1978, FCM 78-1.

ISSUING AND DISSEMINATING WARNINGS AND FORECASTS

In response to the need for streamlining and improving field operations, NWS has a significant automation effort underway to increase the productivity of its operating personnel and the effectiveness of its forecast and service offices. The Automation of Field Operations and Services (AFOS) Program is designed to apply modern methods of data handling, display, and communications to enable the field offices to provide more effective forecast and warning services to the Nation. Minicomputers, mass storage capability, TV-type displays, and hard-copy devices modularly assembled will be used to equip a systems monitoring and coordination center, 4 national centers, 6 satellite field services stations, 13 river forecast centers, 52 Weather Service Forecast Offices (WSFOs), and 136 Weather Service Offices (WSOs). In addition, the remaining WSOs and the Weather Service Meteorological Observatories will receive only TV-type displays and a hard-copy device. An adjacent office will provide the computer and mass storage support for these offices.

The coordination center, national centers, and the WSFOs will be interconnected with a telephone quality full-duplex communications line called the National Distribution Circuit. Alphanumeric and graphic data will be carried throughout the system replacing several internal teletypewriter and facsimile circuits. In addition, through the use of minicomputers, each WSFO will be interfaced with the WSOs within its area of responsibility. The WSFOs will serve as the collection points for data and act as automated dissemination points for forecasts, warnings, and other information.

AFOS prototype equipment for an experimental WSFO, WSO, and river forecast center has been installed at the NWS headquarters. The NMC is interconnected by means of a communications link with this equipment as an integral part of the model facility. Procurement of the total AFOS system, now underway, will take 4 years. The Departments of Commerce and Defense and FAA are working together to determine how AFOS and other systems will interface to communicate and exchange data.

The general public receives weather forecasts and warnings through several dissemination means designed to reach, either directly or through an intermediary, people engaged in normal day-to-day activities (working, traveling, and recreation). The methods used include teletypewriter (NOAA Weather Wire Service and the press wire services), NOAA Weather Radio, recorded telephones, Coast Guard radio systems, and the mass media (radio, television, and newspapers).

The NOAA Weather Wire Service, operated by NWS, is now available either throughout or in parts of 35 States. About 2,500 subscribers are currently using this service. This method is invaluable for reaching the mass media with information, especially warnings of dangerous conditions, for transmission to the public. Department of Commerce provides funds for the lines from an NWS office to a radio or television station or daily newspapers. Subscribers pick up the costs for terminal equipment and for connection and local line charges. Other subscribers are at liberty to connect to the NOAA Weather Wire Service at their own expense for the lines in addition to all other charges. Plans for nationwide expansion of the NOAA Weather Wire Service within the remining States will not be completed at this time to effect savings recommended by the Office of Management and Budget.

The NOAA Weather Radio, also operated by NWS, provides continuous radio broadcasts out about 40 miles from the transmitter site on 162.4, 162.475, or 162.55MHz. In a policy statement issued by the Office of Telecommunications Policy of the Executive Office of the President on January 13, 1975, the NOAA Weather Radio was designated as the only Federally sponsored method for the transmission of disaster warning information to receivers optionally available to the general public. A variety of receivers are available on the market. An increasing number of manufacturers are including a "weather button" as part of a regular AM/FM radio. Special receivers with warning-alert features are especially important in disseminating warnings to disaster agency and police officials, schools, institutions, and local governmental offices, as well as commercial radio and television stations. This service is now provided from about 170 locations. Additional installations planned over the next year will bring the total number of transmitters to about 340.

The National Weather Service, the Federal Communications Commission, the Defense Civil Preparedness Agency, and the National Industry Advisory committee (which represents the broadcast industry) are collaborating to develop State and local disaster warning dissemination procedures for the Emergency Broadcast System (EBS). The use of EBS will complement the NOAA Weather Radio in the dissemination of warnings.

ARCHIVING WEATHER INFORMATION

Collecting, summarizing, archiving, and retrieving of data are climatological activities within the Basic Meteorological Service. Climatology includes the continuing use of historical weather data for long-range planning and for improving knowledge of weather and its effects upon life, property, energy resources, and economic development. The National Climatic Center at Asheville, N.C., receives and processes over 30 million meteorological observations annually and makes data and summaries including satellite data and related products available to a large and diverse user community. Data are gathered from NWS, the National Environmental Satellite Service, military services, and international sources to provide a National Climatic Data Base (both digital and analog) for multiple uses. Over 80,000 subscribers regularly receive published data. The data and publications are used by planners, designers, engineers, lawyers, academic groups, government agencies, and the public. General publications serve the needs of broad user audiences. The Climatic Atlas of the United States presents widely used climatic data in graphic forms and tabulations. Climatological Data National Summary, issued monthly, lists pressure, temperature, and wind data for a large sampling of selected stations. Local climatological data publications are issued monthly for about 300 cities; these contain daily and monthly data on temperature, heating and cooling degree days, dewpoint, precipitation, wind, sunshine, and clouds. Other publications are designed to meet specific needs

of large user groups. These include development of data archiving systems and studies undertaken for:

- ground-based analyses of the state of the atmosphere;
- the interrelationship between satellite-based weather observations and surface observations as sources of integrated data products;
- the statistical nature of climatic change including the interrelationships among various climatic elements over land and water, evaluation of climatic changes integrated over large geographic areas, and man's activities as a cause of inadvertent climatic change;
- the use of large climatic data collections in efforts to improve food production and health, and optimize environmental quality; and
- the use of data analyses in decisions concerning trade-offs between environmental considerations and the economics of construction, power production, location of offshore ports, and mineral recovery on the continental shelf and in deep water.

Because of the increasing importance of climatic fluctuations upon domestic and foreign production of food and fiber, and energy shortages, a Center for Climatic and Environmental Assessment (CCEA) has been established with bases at Columbia, Mo., and Washington, D.C. CCEA operated on a real-time basis during the 1977 growing season, deriving yield estimates from first-generation wheat yield models for Canada, Russia, and the United States.

The yield estimates for these countries were generally close to estimates generated by the Department of Agriculture. Statistical models for other countries are in a final testing phase and will be used in the 1978 growing season. This work represents the NOAA contribution to the interagency Large Area Crop Inventory Experiment. CCEA also has developed models for linking the weather impact to natural gas demand. In addition to the modeling effort, CCEA is globally monitoring weather patterns and issuing weekly assessment reports that relate the impact of anomalous weather conditions to crops and energy demand and distribution. Special weekly reports on the Sahel and Caribbean regions are prepared for the Department of State. Products from this Center are intended to provide information to assist in the management and distribution of our Nation's food and energy resources.

Table 8 lists the costs of the Basic Meteorological Service, by agency, for fiscal years 1978 and 1979.

Operational Program for Fiscal Year 1979

The Department of Commerce plans a net increase of $15,202,000 for Basic Meteorological Services for fiscal 1979. This consists of increases totaling $11,425,000; an adjustment to the base funding for 1978 of $6,813,000 to allow for unavoidable increased costs of ongoing activities; and an offsetting reduction of $3,036,000 directed by the Office of Management and Budget under the Zero Base Budgeting concept that includes the closing of 19 Weather Service Offices.

The Department of Commerce plans to procure radar data processing (RADAP) equipment for 56 network and 15 local warning radars to provide coverage for the geographic areas that are most subject to flash floods. RADAP also will replace remote systems now used at some of the Commerce network radar sites. Operating with existing radar facsimile display recorders, it will enable NWS forecast and warning offices, and other users of radar data to dial in and directly obtain the radar facsimile picture in near-real time. $2,550,000 is requested to begin a 5-year procurement plan to complete implementation of the RADAP in 1985. $260,000 is being requested to provide program management and procurement of five advanced engineering prototypes of the Shipboard Environmental Data Acquisition System. The system automatically acquires marine data and relays them back to shore via satellite communications.

An increase of $500,000 is planned to establish a center for climate studies that will help focus the Nation's research to create a credible climate forecast capability.

Another $2,108,000 is being requested to automate fully the existing upper air tracking system. Full automation and replacement of outdated subassemblies on the existing tracking systems will eliminate the remaining manual steps required in the reduction of upper air sounding data and reduce excessive maintenance and logistics costs.

An increase of $831,000 is planned to provide staffing through State employees for the NOAA Weather Radio network. The completed network of over 330 stations will put 90 percent of the population within listening range of direct broadcasts of weather forecasts and warnings as well as warnings of other natural disasters and nuclear attack.

Table 8—Basic Meteorological Service costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting Research		Total	
	FY 78	FY 79	FY 78	FY 79	FY 78	FY 79
Commerce	256,053	271,255	15,794	17,249	271,847	288,504
Defense:						
Air Force	33,707	34,469	—	—	33,707	34,469
Navy	7,606	8,559	—	—	7,606	8,559
NASA	—	—	21,538	32,630	21,538	32,630
Transportation:						
Coast Guard	2,107	2,349	—	—	2,107	2,349
FAA	8,765	8,232	—	—	8,765	8,232
TOTAL	308,238	324,864	37,332	49,879	345,570	374,743

An increase of $1,000,000 is projected to complete the Community Preparedness Program for most of the remaining States so that urban and rural communities will be better prepared to cope with major natural disasters.

A request for $300,000 would improve the Center for Climatic and Environmental Assessment's operational capability to determine the impact of climate change on our Nation's resources. An increase of $1,100,000 is planned to modernize the data management procedures of the National Climatic Center.

Another $350,000 request would provide marine weather support for the Gulf of Mexico from the Kansas City Satellite Field Services Station, and $125,000 to increase the Anchorage Station operations to 24 hours per day. A $250,000 increase would enable studies to begin directed toward determining the requirements for the next generation of polar-orbiting and geostationary satellites.

A net decrease of $3,261,000 is planned for polar-orbiting satellites. This includes an increase of $1,756,000 needed to procure two solar backscatter ultraviolet instruments and a solar and Earth radiation monitoring instrument to be carried by NOAA spacecraft. This will be offset by a decrease of $5,017,000 for the accrued costs of the TIROS-N series spacecraft and instrument procurements.

An increase of $3,638,000 is requested to reimburse USAF and NASA for launch vehicles and services. A decrease of $2,280,000 will result from completing installation of ground equipment hardware and software needed to operate the TIROS-N series spacecraft and to maintain the TIROS-N series ground system.

In geostationary satellites, a decrease of $1,700,000 is planned for costs of spacecraft procurement. An increase of $5,697,000 is requested for incremental costs associated with procurement of launch vehicles. An increase of $1,548,000 is planned to reimburse NASA for postflight charges on GOES 1 launch services. A decrease of $2,501,000 will result from nonrecurring costs for launch services and ground equipment.

Table 9 shows the planned launch schedule for polar-orbiting and geostationary satellites by the Department of Commerce.

In the Department of Defense the Air Force attributes 16 percent of its operational program to Basic Meteorological Service; therefore, of its planned program changes, a net increase of $762,000 will be applied to this service. The Navy plans an increase of $953,000 attributed principally to costs of computer supplies, spare parts, and maintenance, as well as communications. Discussion of the Air Force program changes will be found under General Military Meteorological Service.

Research Program for Fiscal Year 1979

In the Department of Commerce, the initial AFOS installations will become operational and AFOS equipment will be installed at many additional sites. Research and development activities will continue at a high level with emphasis on the operational evaluation of the AFOS system. Specific design, development, experimentation, and refinement of the AFOS system's hardware and software will be made during fiscal 1979. Included will be work on human factor design and analysis, detailed forecast area designs, data acquisition processing and interface design, external users' interfaces, and the extension of AFOS capabilities to the rest of NWS. Simulation experiments will be made in both the experimental facility and the initial AFOS field sites to validate forecast applications for monitoring and updating NWS predictions and warnings.

New weather products and better services will be developed to take advantage of the advanced technology of the AFOS system. New meteorological forecast applications will involve the automatic monitoring and updating of forecast guidance as needed, the automatic production of guidance in the same form as the final products, and the introduction of new products relative to a local area.

Table 9—Projected launch schedule for Polar Orbiting System and Geostationary System

Polar Orbiting System: Satellite designator	Planned launch date	Instruments
TIROS N (NASA funded)	3Q FY78	AVHRR—Advanced Very High Resolution Radiometer; TOVS—TIROS N Operational Vertical Sounder; SEM—Space Environment Monitor; DCPLS—Data Collection and Platform Location System; HIRS/2—Modified High Resolution Infrared Sounder.
NOAA A	4Q FY78	
NOAA B	FY 1979*	
NOAA C	FY 1980*	
NOAA D	FY 1981*	
Geostationary System: Satellite designator	**Planned launch date**	**Instruments**
GOES C	3Q FY78	VISSR—Visible and Infrared Spin Scan Radiometer; SEM—Space Environment Monitor; DCS—Data Collection System; VAS—VISSR Atmospheric Sounder (GOES D and Subsequent spacecraft).
GOES D	FY 1980*	
GOES E	FY 1981*	
GOES F	FY 1983*	

**Launch date depends on performance of prior spacecraft.*

One AFOS forecast application is the automatic generation, update, and display of computer-worded public forecasts. This effort involves the development of complete, objective, three-period (e.g., today, tonight, and tomorrow) automated forecasts in a worded form suitable for use by NWS public forecasters on a real-time basis. The forecaster can accept the computer-produced forecast, push a button on the AFOS console and the dissemination will be automatic. Slight alterations can be made by simple text editing. Forecasts can be changed completely by entering a new set of forecast values in lieu of the objectively derived ones, and instructing the AFOS minicomputer to generate a new forecast for dissemination.

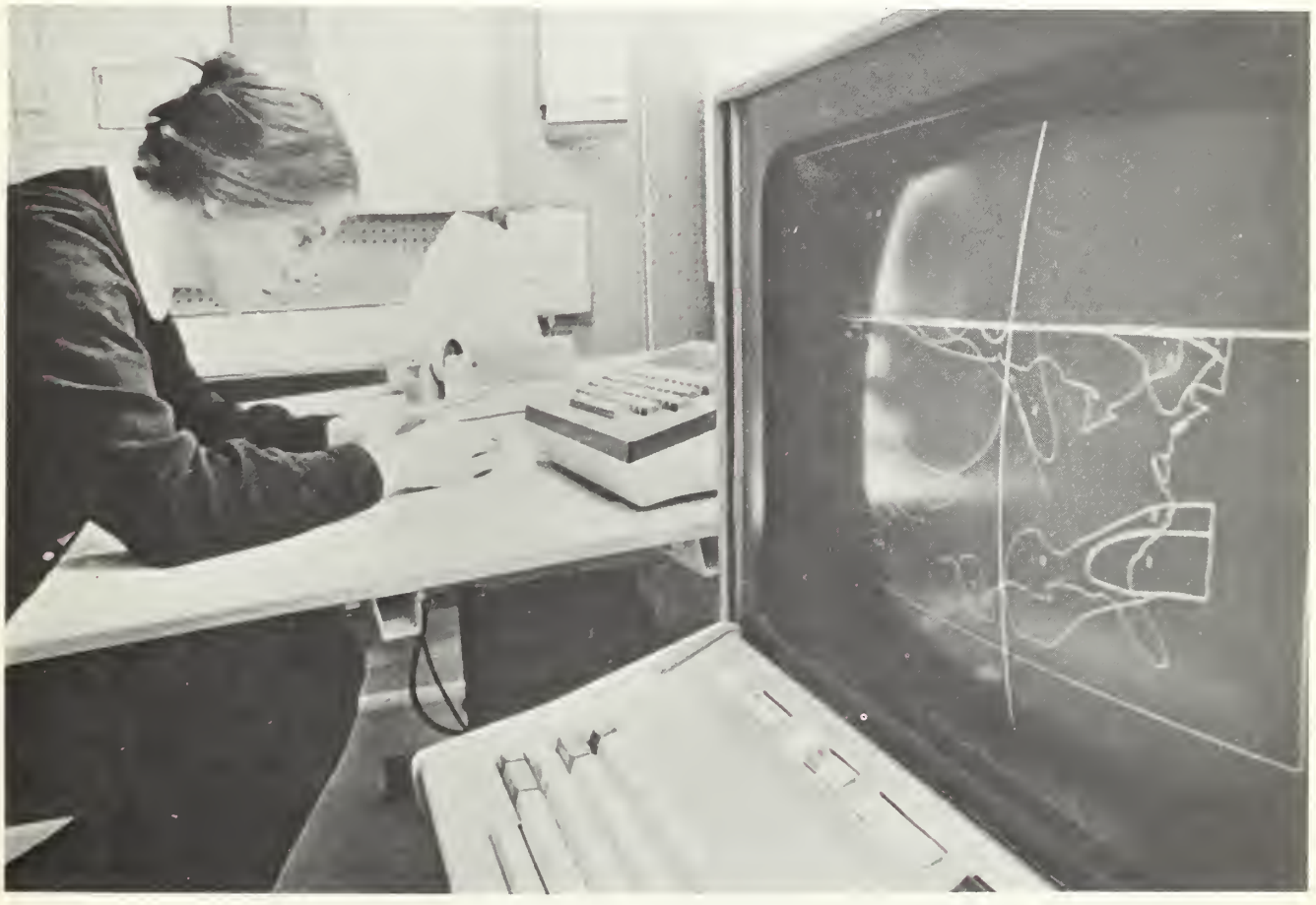
In fiscal 1979, tests will be run in the AFOS Experimental Facility and at field locations to determine forecaster acceptance of the form of display, structure of the message, and complexity of the forecast. The program will be modified to make forecasts for additional stations. Terminology unique to a particular station will be developed and incorporated when ready. The program will be expanded to handle a tonight, tomorrow, and tomorrow night cycle.

Also of vital importance is a new effort aimed at the automation of guidance to NWS forecasters who are responsible for issuing flash flood warnings and advisories on a real-time basis. The flash flood forecaster will be able to request, via the AFOS console keyboard, information regarding probable maximum precipitation amounts based on derived correlations between radar data and precipitation amounts.

Automated public weather guidance forecasts prepared from Model Output Statistics (MOS) are now available to NWS field forecasters. Precipitation, temperature, clouds, and wind are predicted for over 230 locations in all States except Hawaii. These forecasts will be expanded and refined in both time and space. In addition to more locations, zone forecasts will become part of the new computer-worded forecasting system. The probabilities of fog, drizzle, sleet, snow, and other hydrometeors will be expanded to include more details of intensity and duration.

Of particular importance in the MOS system are improvements in the statistical methods used and in the generalization of the approach. Research is continuing in this area. Development of a method for incorporating nonlinear information has been especially encouraging.

Interaction among TDL researchers and various operating units has improved verification procedures and quality-control feedback. These efforts will be expanded, with coordination on minicomputer software, enabling forecasters



Observers in the Air Force Global Weather Central use the Phase I Interactive Processing and Display System to build severe weather graphic products. Products are constructed via a digitizing table with data displayed on a CRT for verification. This operation allows simultaneous creation of a facsimile and graphic teletype product.

to interact with objective procedures. Such efforts will help solve problems of local wather forecasting. Improvements are expected in forecast skill, consistency of products in time and space and among elements, and more complete early guidance packages with more elements predicted at more locations. These improvements are anticipated through advances in statistical techniques for both probabilistic and categorical forecasts, additional predictive information, and the interactive capabilities that AFOS makes available to the human forecaster. An important effort will be to determine the degree of use and the value of such guidance.

Research continues in developing and refining automated techniques for forecasting thunderstorms and severe local weather (e.g., tornadoes, hail, and damaging winds) in each of the key ranges: medium, short, and very short.

The objective of research in medium-range forecasting is to develop automated techniques for predicting general thunderstorm activity and the occurrence of severe local storms for projections of 12 to 48 hours. In fiscal 1979 the operational probability equations will benefit from detailed forecasts of low-level temperature, moisture, and wind generated by an advanced boundary-layer model. Upper level predictors will be supplied by a limited-area fine-mesh numerical model. An early guidance package based on 1200 GMT initial data will be developed to provide NSSFC with thunderstorm and severe local storm probabilities for a 24- to 48-hour forecast projection. Procedures will also be developed to update severe local storm probability forecasts by using synoptic observations, satellite data, and radar reports.

Efforts in the short range will focus on improving and expanding current 2- to 6-hour forecasts of thunderstorms and severe local storms. Improvements may result from application of new statistical prediction techniques, introduction of new predictor variables that integrate separate parameters related to storm events, longer developmental data samples, and new predictor data sources. New data sources that may become available in fiscal 1979 are:

- Output from a numerical boundary layer model now being readied for implementation, and
- Digital satellite data.

Forecasts will be extended to include the cool season and will be increased from four to six forecasts daily.

The goal of research and development in the very short range is to develop automated 0- to 2-hour forecasts of local convective weather. Primary reliance will be placed on NWS digitized weather radar and associated radar data processing systems (RADAP) to identify, track, and forecast the development and movement of thunderstorms. Of particular interest are thunderstorms with associated severe weather. Techniques are being developed with two goals in mind:

- Determining the likelihood of a particular thunderstorm having severe weather associated with it and
- Forecasting thunderstorm development and motion, and assessing the probability of severe weather in a given locality.

Initially, the forecasts will be derived primarily from NWS digital radar data. Later, other types of meteorological data will be included through the use of the AFOS communication system. Results should be useful in providing timely warnings to the general public as well as to special users such as the aviation industy. A real-time test of these products is planned for fiscal 1979 in connection with air traffic control.

Since the lower atmosphere strongly influences severe local storms, work is continuing on developing a three-dimensional numerical forecast boundary layer model to aid in severe storm prediction. Output will consist of detailed profiles of wind, temperature, and humidity. These will be incorporated into severe storm prediction equations for use as guidance to NSSFC and field forecasters. Work in boundary layer modeling during fiscal 1979 will include:

- Extending the model westward to cover the 48 contiguous States,
- Extending the model upward to eliminate dependence on the LFM model for upper boundary conditions, and
- Studying the feasibility of telescoping the model to produce fine-mesh forecasts over limited areas.

The National Hurricane and Experimental Meteorology Laboratory will continue research directed toward beneficial modification of specific weather events, and developing improved techniques for predicting formation, movement, and changes in intensity of hurricanes. These efforts will include special observational programs using research aircraft, meteorological satellites, weather radar, and upper-air (balloon) and surface observations; and diagnostic studies of both hurricane and cumulus structure, behavior, and interaction with the large-scale structure. Special efforts will continue to improve both the two- and three-dimensional mathematical models that already represent the most sophisticated existing for the numerical simulation of mesoscale behavior and structure of hurricane and cumulus phenomena. The efforts of the Laboratory will rely heavily on the newly completed research aircraft capability, which represents one of the world's most sophisticated airborne observing platforms for atmospheric studies.

A major part of the activity in applied research on hurricane prediction is carried out in the operational environment of the National Hurricane Center by its research and development unit. This effort has now been expanded to provide guidance for hurricane forecasters in the Eastern Pacific as well as on the Atlantic side.

Research and development on automatic weather stations continues to concentrate on automating those parts of the observation that still require manual input. The most recent step forward was automation of cloud and visibility information. Development efforts include work on a laser system for observing the "present weather" parameters—rain, snow, sleet, smoke, and fog.

Department of Commerce research programs for meteorological satellites will continue to emphasize derivation of quantitative data from satellite observations of the Earth's atmosphere and surface. These data will be used to develop improved techniques for environmental prediction and warning. Major efforts in the data applications program include derivation of temperature and moisture fields, wind vectors, energy balance, and concentrations of ozone and other atmospheric constituents. During fiscal 1978, NESS will continue to cooperate with NASA in the development of the VISSR Atmospheric Sounder (VAS). VAS will be included on the GOES D, E, and F spacecraft in lieu of the current VISSR.

Research objectives of the National Severe Storms Laboratory are:

- To improve the capability of storm sensing and warnings through sensor development such as Doppler radar and communication-display systems application, and

- To improve thunderstorm and tornado forecast capability through application of increased understanding of severe storm circulation and dynamics derived from melding observations with numerical and laboratory models.

The important capability of multiple Doppler radars to measure the wind circulation both within cloud and outside cloud (clear air) is being used to determine the dynamics of initial cloud formation and the role of wind structure in the development of tornado-producing mesocyclones. Concurrent measurements of meteorological parameters obtained from observational systems consisting of surface stations, a 450-m instrumented tower, rawinsondes, aircraft, and conventional radar are combined with the Doppler data for thunderstorm model development.

Mesocyclone signatures foreshadowing tornado development and tornado vortex identification by Doppler radar are being evaluated for operational use in a cooperative program under which NOAA, Department of Defense, and Department of Transportation are trying to improve severe storm detection and warning for both the general public and aviation. Also being evaluated is the incorporation of Doppler radar capability and computer-processed color-coded displays into a new generation of radars to replace the present outmoded system.

Maximum tornadic winds to be considered in structural design criteria for critical structures such as nuclear reactors is one object of field studies involving mobile teams for photographic recording of tornadic events. These studies, combined with numerical and experimental tornado models, are supported by the Department of Energy and the Nuclear Regulatory Commission. Photographs and movies are also being used in preparing a spotter's guide program for NWS use.

Atmospheric electricity generation, its location and discharge path, its relationship to aviation weather hazards, and ground severity are being addressed through innovative lightning direction and detection capability correlated with Doppler-observed wind fields within the thunderstorms.

The Wave Propagation Laboratory will continue development of a ground-based, airborne, and eventually satellite-mounted coherent infrared lidar system for remotely measuring winds. The ground-based system will be constructed and tested. Construction of the airborne system and design of the satellite system also will begin.

Work will continue on microwave radiometric systems to measure temperature and water vapor remotely, and provide quantitative measurements of rainfall. Radiometric techniques will be tested for use as flash flood monitors. The feasibility of

Extensive property damage in Scituate, Massachusetts caused by a winter storm in February 1978. Courtesy of United Press International.

using radiometric techniques on data buoys for measuring profiles of temperature and humidity will be assessed.

The capability of FM-CW radar and Doppler radar for maintaining continuous surveillance of the three-dimensional wind field in a local area will be used by the development of real-time data processing and display systems. Work will begin on deriving three-dimensional temperature and buoyancy fields from the Doppler wind data.

The Wave Propagation Laboratory will continue to identify the limits and capabilities of acoustic sounder systems for measuring all types of atmospheric phenomena, including profiles of wind and temperature. Study will continue on the extent to which observation of rainfall-induced scintillations can be used to measure the total amount of rainfall on a line-of-sight path.

Under NOAA's Environmental Data Service (EDS) the Center for Climatic and Environmental Assessment's efforts aimed at modeling the impact of climate variability on our Nation's resources will be expanded from wheat to other crops such as corn and soybeans. Work will proceed on developing a second-generation model that will include other parameters (heat stress and water budget) and be more responsive to agronomic weather factors affecting crop growth. Work will also begin on development of climate/fish models to link up climate change to fish catch over large areas.

The Center for Experiment Design and Data Analysis (CEDDA), also under EDS, will devote increased effort to the analysis of data collected during the GARP Atlantic Tropical Experiment, with emphasis on the description of convective systems and planetary boundary processes over the tropical oceans. CEDDA will also continue to develop a program of empirical studies of climate data aimed at describing the temporal and spatial coherence of large-scale meteorological and oceanic variations, with emphasis on 1- to 10-year time scales. Work will begin on the development of analysis, validation, and quality-control procedures to be used in processing oceanographic data collected during the Global Weather Experiment. The results of this effort will assure the

Extreme snowfall accumulation is shown in Hamburg, New York as a result of winter storms.

availability of a consistent, well-documented, conveniently formatted set of oceanographic data for use by researchers and climatologists, and for archiving in the World Data Centers.

The NASA Weather and Climate Program is concentrating on:

- Space and ground systems development for detecting, predicting, and warning of severe storms;
- The application of space technology to improve long-range forecasting (1-3 weeks); and
- Establishing the potential of space technology in monitoring and predicting climate changes.

The NASA-developed TIROS-N, planned for launch in May 1978, is the prototype of the next generation of operational weather satellites. It will provide global monitoring of weather systems and highly accurate quantitative measurements of the atmospheric state. TIROS-N and the operational follow-on satellites (funded by NOAA) will provide direct support to the National Weather Service and the international Global Atmospheric Research Program (GARP). NASA will participate in the analysis of GARP-produced data, particularly data acquired from space, in the development of advanced modeling and prediction techniques. NASA also will develop advanced instrumentation for the TIROS-N series of satellites to improve atmospheric soundings, produce higher spatial and temporal resolution imagery, and provide better observations of the distribution and total content of atmospheric constituents such as ozone.

NASA is using space and aircraft technology to obtain an improved understanding of the dynamics of severe storms such as thunderstorms, tornadoes, hurricanes, and typhoons. Development of models and forecast techniques using satellites, aircraft, and other data to improve the prediction of severe storms is underway. This research also will lead to the specification of new space capabilities for severe storm observation, detection, and prediction. The NASA-developed VISSR Atmospheric Sounder (VAS) will be launched in 1980 on the Geostationary Operational Environmental Satellite (GOES) to provide measurements of the vertical structure of temperature and humidity in the vicinity of severe storms. This will be the next step in developing a space capability for the detection and monitoring of these storms.

An Atmospheric Cloud Physics Laboratory (ACPL) will be flown on Spacelab III in 1981 and twice per year thereafter. The ACPL will significantly increase the level of knowledge of cloud microphysical processes. The low-gravity environment in orbit will allow cloud physics experiments to be performed under conditions similar to, and for time periods identical to, those occurring in nature—something that cannot be done on Earth. The experimental results will then be used to improve severe storm models and severe weather prediction techniques.

Selected experiments will be conducted that capitalize on the geostationary meteorological satellite capabilities for localized adverse weather conditions. An experiment in improved detection and prediction of frost and freeze conditions in Florida was initiated in fiscal 1977 and will be brought to operational capability during fiscal 1979.

NASA climate research covers the long-term characteristics of the atmosphere-ocean-land system and will emphasize the understanding of the physical basis of climate. NASA efforts will be directed mainly toward climate modeling and the development of a space-observational capability. Space data already gathered can yield information vital to national climate interests when additional analyses and corroborative data are collected. These data include global total ozone measurements from Nimbus 4, global precipitation, soil moisture, snow, and ice cover from the microwave sensors of Nimbus 5, and important data on the Earth's radiation budget from Nimbus 6. These climate analyses will incorporate additional data on atmospheric constituents from Nimbus G (August 1978) and oceanographic data from SEASAT-A (May 1978) when these satellites are launched.

NASA studies, conducted with leading climate scientific investigators and in conjunction with national planning for climate research, have served to identify climate modeling and data requirements that can presently be measured on the required global basis by satellite techniques. One of these requirements is a global determination of the components of the Earth's radiation budget. The Earth Radiation Budget Satellite System (ERBSS) will be a three spacecraft system designed to meet this need. Launching of the three spacecraft is scheduled during 1982.

Most of NASA's $11 million increase for meteorological research is due to the ERBSS fiscal 1979 new start, preparation of ACPL for shuttle launch, operations and data analysis support for Nimbus G, and data analysis support for FGGE.

Aviation Meteorological Service

Description

The Aviation Meteorological Service furnishes specialized weather information to pilots, dispatchers, air traffic controllers, and fixed base operators to promote safety, efficiency, and operational effectiveness in civil and military aviation. Responsibility for the Service is shared among three Federal Departments—Commerce, Transportation, and Defense.

- The Department of Commerce provides meteorological services used by domestic and international civil aviation, and is responsible for meeting the common requirements of other agencies.
- The Department of Transportation makes recommendations to the Department of Commerce on civil aviation meteorological services, provides specialized equipment and surface observations at certain airfields, disseminates weather information to users, and distributes weather data over civil teletypewriter systems.
- The Department of Defense serves the specialized global needs of military aviation and makes meteorological information from its facilities available to civil aviation.

Specialized surface observations, primarily in support of aviation, are made at 525 civil and military locations in the United States. On the civil side, NOAA provides surface observations taken solely to support aviation requirements at 8 locations and FAA at 348 locations. The remainder are provided by the Department of Defense. These figures do not include cooperative observations by private operators at many smaller airports and by those supporting the Basic Meteorological Service. At several locations the surface observation program is coordinated between NOAA and FAA or Department of Defense.

Pilot reports supplement surface observations by describing weather conditions encountered by aircraft in flight. They are valuable for pilot weather briefings and as data for the preparation and updating of forecasts and warnings. Since October 15, 1976, domestic pilot reports have been prepared in a standardized format. International pilot reports continue to be encoded in their own standardized format.

Weather observations and other information in support of domestic civil aviation are collected and distributed over the FAA digital data Service A and the Basic Meteorological Service teletypewriter systems. Department of Defense agencies use a continental U.S. meteorological communications system to meet the needs of military aviation and ground units in the United States. International meteorological data are exchanged on high-speed circuits of the Basic Meteorological Service, and, where necessary, on the Aeronautical Fixed Telecommunications Network operated by FAA. The Automated Weather Network of the Department of Defense provides for high-speed collection and relay of data between overseas areas and the continental United States to meet Department of Defense aviation and other military requirements. Data from this system are provided to the National Meteorological Center (NMC) as an essential ingredient to NMC's data base. NMC places selected North American data on the Department of Defense network for distribution to military users.

Analyses and forecasts for aviation are prepared by weather centers, and by weather forecast and service offices. National centers of the agencies provide guidance and forecasts for use by lower echelon forecast offices. The Department of Defense also prepares computer flight plans—an average of 850 to 950 daily—to support worldwide tactical and strategic aircraft movements. Cooperative efforts are in being to facilitate the exchange of information between agencies. For example, at the Navy's Fleet Weather Central in Hawaii, a National Weather Service representative assists in computer programming/and adapting Navy products for use by the National Weather Service in the Pacific region. At Suitland, Md, a Joint Ice Center established at the Naval Fleet Weather Facility provides operational sea ice analyses and forecasts to the civilian community as well as to the Department of Defense. Also, Fleet Weather Facility Suitland provides a communications capability for transmitting backup products from the Fleet Numerical Weather Central to the National Meteorological Center and for certain National Environmental Satellite Service products to the Naval Weather Service. If the NMC's computational center should experience a significant outage, arrangements have been made, as outlined in the *Federal Plans for Cooperative Backup Among Operational Processing Centers,* December 1976, FCM 76-4, for the Air Force Global Weather Central to provide aviation wind forecasts for commercial flight planning.

Analysis and forecast centers of NOAA distribute specialized aviation weather charts to weather offices and briefing facilities, which include Weather Service Forecast Offices (WSFOs), Weather Service Offices (WSOs), FAA Flight Service Stations (FSSs), and Department of Defense's military offices, over the several facsimile networks. The Department of Defense supplements NOAA's aviation weather charts with additional facsimile charts to meet its specialized requirements.

Fifty-two NOAA WSFOs (including San Juan) prepare detailed local forecasts for 481 terminals and 328 routes on a scheduled basis, and six NOAA WSFOs provide forecasts for international civil aviation for the North Pacific, North Atlantic, and Caribbean areas and for Central America and West Europe according to procedures of the International Civil Aviation Organization. Department of Defense depends upon NOAA forecasts for common terminals and has a few weather service offices that also support international civil aviation.

Aviation weather briefings by FAA and the Departments of Commerce and Defense are available to pilots through 638 manned facilities. At air terminals where FAA-FSS and NOAA-WSO facilities are collocated, the FSS handles routine weather briefings and refers the pilot to the WSO or nearby WSFO for more technical meteorological assistance if necessary. FAA maintains extensive weather briefing outlets. These outlets include toll-free telephone service from many airports that do not have a local weather briefing service, recorded forecast and observation material at more than 60 locations available by telephone, scheduled broadcasts over more than 800 air navigational aids, and separate continuous transcribed weather broadcasts from 150 radio outlets. Pilots may also get weather information by direct radio contact with a Flight Service Station. At 38 FSSs throughout the country, specially trained personnel provide additional air-ground radio service to pilots over a discrete radio frequency 16 hours daily. A network of 44 FSSs should be completed by mid 1978. This service, designated Enroute Flight Advisory Service, maintains a continuous weather watch, provides time critical assistance to enroute pilots facing hazardous or unknown weather, and recommends alternate or diversionary routes. These flight watch control stations are also focal points for rapid receipt and dissemination of pilot reports and other weather information.

The Department of Defense provides air-ground radio service for unique military requirements. This service transmits observations, forecasts, warnings, and other meteorological data tailored to military application transmitted to Department of Defense aircraft upon request; in return, inflight weather reports are passed to the ground.

FAA provided over 16 million pilot weather briefings last year, the Department of Defense about 2 million, and NOAA about 1 million. FAA projects a continuing annual increase in requests for weather services from its Flight Service Stations, i.e., 18.4 million for fiscal 1978 and 21.1 million in fiscal 1979.

NWS and FAA are collaborating to implement a Center Weather Service Unit (CWSU) at each of 13 Air Route Traffic Control Centers (ARTCC). The program will be funded by FAA. Each of the CWSUs is being staffed with 3 professional meteorologists. Using meteorological forecasts and observations available from radar, weather satellites, pilot reports, weather facsimiles, and weather teletypewriter circuits, the CWSU meteorologists will monitor aviation weather conditions within the area of responsibility of the ARTCC to which each unit is assigned and will keep the flow controller apprised of changing weather conditions. Particular emphasis will be applied to those situations that would be hazardous to aviation safety and impede the flow of air traffic in the National Airspace System. They will also solicit and disseminate pilot reports, provide both scheduled and special-purpose briefings to Center personnel, and provide weather training for Center personnel. Support concepts for the CWSU have been demonstrated in part by an experimental weather unit in the Kansas City ARTCC jointly operated by NWS, the Department of Defense's Air Weather Service, and FAA. The experimental unit will be discontinued in mid-1978 as the CWSU is phased in.

Table 10 lists the costs of Aviation Meteorological Service, by agency, for fiscal 1978 and 1979.

Operational Program for Fiscal Year 1979

The Department of Defense is planning a net increase of $2,977,000. The bulk of the projected increase is in the Air Force program. Details are discussed under General Military Meteorological Service.

In the Department of Commerce, the difference in program amounts is due solely to adjustments to base funding.

Note: FAA costs for operations in table 10 do not reflect the costs of operations, facilities, and equipment in the 13 CWSUs for fiscal 1978 and 1979. The CWSUs started operating in April 1978. It is estimated that these costs for fiscal 1978 will be about $2 million. Recurring equipment and personnel costs for the 13 CWSUs are estimated to be about $1.7 million. However, for fiscal 1979 this amount could be higher if equipment procurement is not completed in 1978.

Research Program for Fiscal Year 1979

FAA is formulating an Aviation Weather System Program to improve the aviation weather support provided to the National Airspace System and its users through the 1980s and beyond. Center Weather Service Units (CWSU) are being established in Air Route Traffic Control Centers as one feature of this program. The technical activities to be pursued in the course of the CWSU development are:

- Initiate detailed system functional specification and engineering design activities,
- Establish a CWSU at each ARTCC to provide real-time professional meteorological support to the controllers and to

Table 10—Aviation Meteorological Service costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 78	FY 79	FY 78	FY 79	FY 78	FY 79
Commerce	19,910	21,586	35	35	19,945	21,621
Defense:						
Air Force	128,509	131,415	—	—	128,509	131,415
Navy	10,032	10,103	2,052	2,618	12,084	12,721
Transportation:						
FAA	59,070*	60,487*	11,733	13,627	70,803*	74,114*
Total	217,521	223,591	13,820	16,280	231,341	239,871

**See Note under Operational Program for Fiscal Year 1979*

expedite the handling, processing, and dissemination of PIREPS,

- Improve the detection, measurement, and tracking of wind shear conditions,
- Increase the number, quality, and frequency of surface aviation observations through automation,
- Improve hazardous weather training for pilots and controllers. Determine what degree of weather avoidance responsibility controllers will be able to accept,
- Improve very short range (5- to 15-minute) aviation weather forecast accuracy and reliability through an interagency development effort with NWS and USAF, and
- Improve inflight and preflight briefing effectiveness and efficiency through the FSS Automation Program, and survey and review the weather information now and potentially available to AWES for purposes of establishing system data base requirements.

FAA plans to automate at least 43 of the most active Flight Service Stations followed by consolidation of the present domestic 292 Flight Service Stations into 20 new Hub facilities at the 20 Air Route Traffic Control Center (ARTCC) locations. However, the potential difficulties of consolidation have led to an alternate plan that will meet system demands without consolidation, but with automation extended from 43 up to a maximum of 150 Flight Service Stations in the same time frame as the total consolidation plan. It is emphasized that 150 is the upper limit on the ultimate configuration for costing purposes and is not the selected alternate configuration. This alternative does not require, nor preclude, the closing or consolidation of the remaining 142 manual Flight Service Stations. The issue of consolidation will remain under consideration, and a decision on which plan will be followed will be made before 1983.

For either plan, about 1,200 specialist display consoles will be required. In the 20-Hub plan, all equipment, displays, and specialists will be located in the Hub facilities at the ARTCCs; whereas, in the alternate plan, the displays and specialists would be located in as many as 150 Flight Service Stations. In both plans, a major computer system will be in the 20 existing ARTCCs.

The implementation approach and costs of both plans are almost identical for the first 5 years of the program (through 1982). Consequently, the consolidation decision can be delayed without affecting program costs. A procurement request will be initiated in early 1978 for the competitive procurement of computer systems to be located at 14 ARTCCs that will be connected with specialist terminals in at least 43 of the busiest Flight Service Stations. These systems will be in place starting in late 1980 and will be fully operational starting in mid-1981. These systems will subsequently be upgraded with additional data processing hardware and functional

Aviation Automated Weather Observation System (AV-AWOS). Whole sky camera (foreground). Videograph and hail sensor (background). Operational test currently in progress at Patrick Henry International Airport, Newport News, Virginia.

operating capabilities in the 14 ARTCCs. The upgraded systems will also be installed at a later date at the remaining 6 ARTCCs. This will provide the necessary automation capacity to meet forecasted service demands through 1995 for all specialist operating positions and for self-briefing features for pilots throughout the country.

The inital level of automation will consist of a computer system that will be a subset of the system design for the automated Flight Service Information System. The software will be a relatively simple version that will permit automatic file updating, retrieval, and display of alphanumeric weather and aeronautical data, flight plan entry, and flight plan processing. Each computer system will have a dedicated data communications line from the FAA Weather Message Switching Center (WMSC), and the Automated Service B Data Interchange System (ABDIS).

The upgraded automation system will provide full specialist automation capabilities. An Aviation Weather Processor (AWP) will be added. The AWP will interface with the WMSC for alphanumeric weather data and with NWS's National Distribution Circuit (NDC) for graphic weather products. Each of the 20 computer systems will then receive all alphanumeric and graphic data directly from the AWP. Weather radar data will be received from selected NWS/FAA radars and stored in each computer system for instant retrieval on specialist displays. An initial capability will be provided for pilots to access the data base from privately owned communications terminals, e.g., CRTs and telephone push button devices. A pilot using one of these terminals will be able to obtain a weather briefing, enter a pilot report, or file, close, or cancel a flight plan. Other additions and improvements for pilot self-briefing service are planned and will be added to the system as they become available.

Within FAA, a development program is underway to provide accurate information and warnings of hazardous wind shear conditions to pilots. The program plan includes:

- Efforts to better characterize low-level wind shear;
- Hazard definition of wind shear for the aviation community;
- Development of ground-based devices for hazardous wind shear detection and tracking;
- Development and testing of airborne equipment to assist the pilot in coping with wind shear;
- Wind shear data processing, analysis, and reporting;
- Integration of wind shear data and system into the National Airspace System for use by pilots, air traffic controllers, and NWS;
- Testing of forecast techniques and dissemination methods.

Testing of ground-based wind shear detection and tracking systems will continue in fiscal 1978 at Dulles International Airport where procedures are being developed to pass wind shear information to pilots through the airfield control tower. NOAA, under reimbursable agreements with FAA, has developed remote sensing instrumentation that can measure wind shear. A prototype Doppler acoustic microwave system has undergone operational tests at Dulles. A live tower test is scheduled for 1978 in which the Dulles tower controller will issue wind shear information to pilots in the Dulles airport area. NOAA will also continue to operate a network of pressure jump detectors in conjunction with anemometers at Dulles. At the same time, improvements will be made in the operational capabilities of pressure jump detectors and additional experimentation will be conducted with wind threshold sensors at Dulles. In addition, testing of the low-level Wind Shear Alert System will be completed at six major airports, and specifications are being developed for a 40-system procurement beginning in fiscal 1979. Flight testing and evaluation of wind shear related avionics developed in fiscal 1977 was scheduled to begin in early 1978. Work on the hazard that low-level wind shear presents to various classes of aircraft will continue. The testing and evaluation of techniques to forecast wind shear through NWS also will continue in fiscal 1978.

FAA has a continuing engineering effort to improve existing weather equipment and to develop new instruments for measuring wind, pressure, temperature, visibility, and ceiling. FAA is monitoring the work of other agencies in the area of visibility measurement.

Additionally, FAA is participating in an International Group to standardize RVR measurements. Development of the Aviation Automated Weather Observation System (AV-AWOS) by NWS, with FAA direction and funding, will be completed. The AV-AWOS equipment and software will automatically generate readouts of wind (speed, direction, and gusts), altimeter setting, temperature, dewpoint, visibility, cloud height and cover, and present weather (e.g., yes/no precipitation, freezing rain, hail, and thunderstorms) from sensed data.

These AV-AWOS surface aviation observations will ultimately be disseminated via FAA's Service "A" teletypewriter network, via 1-minute updated terminal weather for cathode ray tube display, and by computer-generated voice over telephone and VOR transmissions. FAA and NWS are beginning development of an Automated Low-Cost Weather Observation System (ALWOS) for use at airports that have approved instrument approach procedures, but currently have no weather observations.

Under FAA funding, NWS will develop improved techniques for short-range (0- to 6-hour) prediction of thunderstorms and low-level wind shear. Thunderstorm forecasts for the 0- to 30-minute time period, with 10-minute update, are planned for FAA air traffic control implementation. The NWS radar system will be used for providing the thunderstorm forecasts. Low-level wind shear forecast techniques will continue to be developed for both frontal and thunderstorm type wind shears for early implementation in the National Airspace System.

Modifications for improving the detection and display of radar reflectivity levels from storm precipitation that may be hazardous to aircraft will be designed for FAA terminal and long-range ATC radars. The feasibility of using FAA airport surveillance radars for detecting wind shear and turbulence that might endanger aircraft also will be investigated. For these functions the radar will be augmented with pulse Doppler processing and with a separately steerable pencil-beam antenna. Wind profiles along the runway glide path and turbulence levels associated with rain storms within the 60-nautical-mile coverage of the radar will be measured.

FAA's System Research and Development Service is analyzing the attenuations to be expected at the two commonly used airborne weather radar, spectral bands "C" and "X". National Climatic Center records collected from NWS weather radars will provide reflectivity and geographic extent.

Five locations will provide data for the primary thunderstorm areas. Airlines will have a basis for making a choice between the two wave lengths.

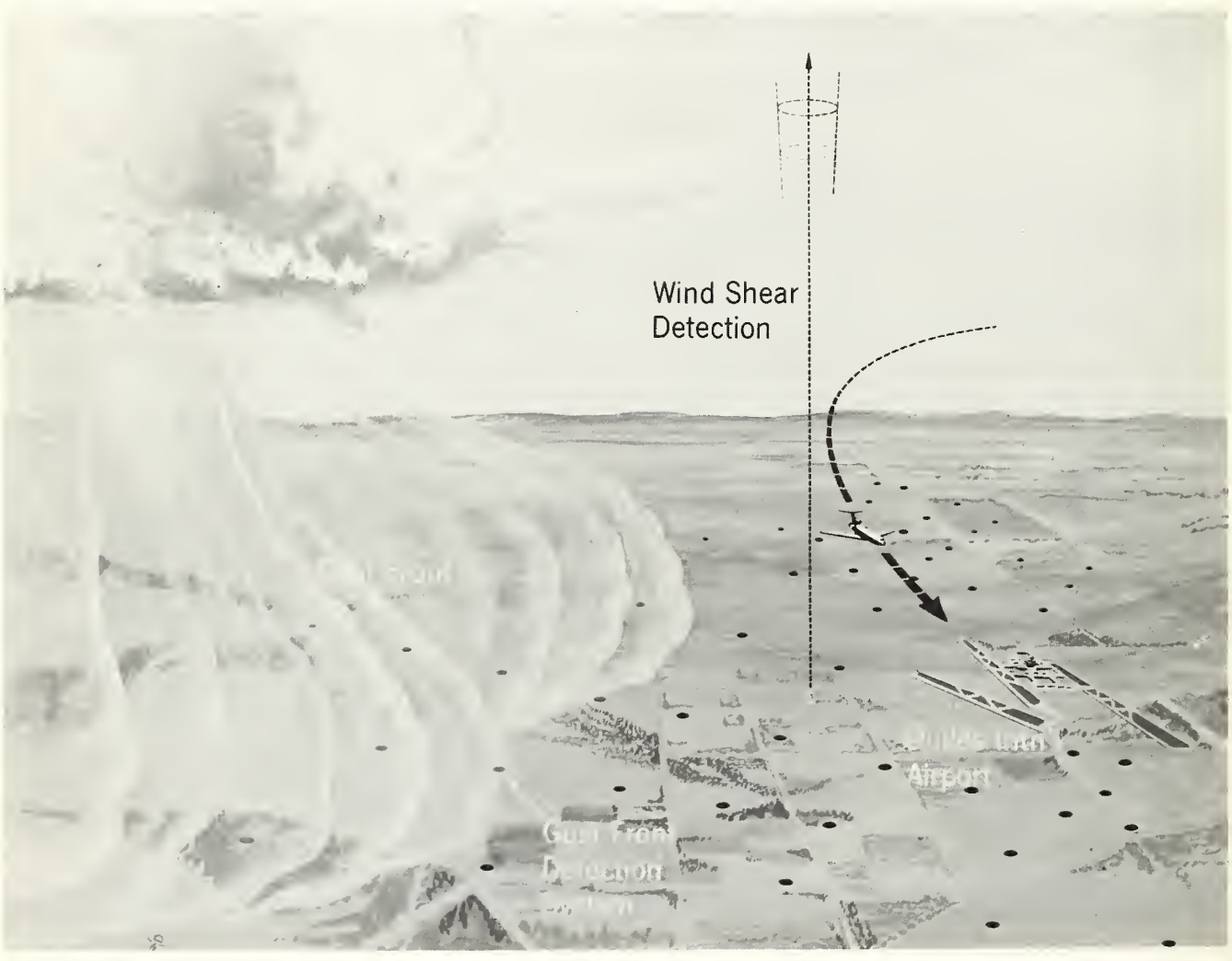
The Department of Commerce (NWS) has an ongoing program to develop improved automated techniques for the prediction of aviation weather elements.

Automated probability forecasts for six operationally important categories of ceiling and visibility are routinely available for 233 conterminous United States terminals four times each day on request/ reply teletypewriter. Terminal forecasts are also provided for 14 Alaska stations. The Model Output Statistics system produces these forecasts. It is expected that the skill of such forecasts will be improved through the use of even more powerful statistical procedures.

The automatic monitoring and updating of aviation terminal weather forecasts will be part of the AFOS software package. An AFOS system minicomputer will automatically compare current surface aviation observations and terminal weather forecasts within each WSFO's area of responsibility to determine if a problem exists. If so, a terminal alerting procedure message will be generated to alert the forecaster to the situation and provide an objective forecast of ceiling or visibility as guidance in revising the official terminal forecast.

NWS research in developing automated techniques for forecasting severe local weather will result in objectively derived probability and categorical forecasts of value to aviation. FAA is particularly interested in how thunderstorms affect total air traffic flow in local terminal areas and enroute travel along designated airlanes.

Department of Defense research efforts are oriented toward specific military requirements and are described in the General Military Meteorological Service section. In general, those aspects related to military aviation services include the application of data gathered from a small-scale network to improvements in short-period terminal forecasts, continued development of techniques for dissipating fog at airfields, and the design of instruments and techniques to support land- and sea-based aviation operations.



Artist's conception of the gust front detection system and wind shear (acoustic Doppler) detection system installed at Dulles International Airport.

Marine Meteorological Service

Description

The Departments of Commerce, Transportation, and Defense share statutory responsibility for the Marine Meteorological Service, designed to promote the efficiency of civil and military marine operations and to ensure the safety of life and property at sea and on coastal and inland waters. Many segments of the economy—including transoceanic, coastal, and Great Lakes Shipping, commercial fishing, offshore drilling and mining, deepwater port activities, and recreational boating—need warnings and detailed forecasts of winds, sea and swell, surf and breakers, ice conditions, anomalous water levels, sea-surface temperature, and ocean current regimes.

- The Department of Commerce is responsible for collecting observations, issuing forecasts and warnings, and disseminating marine meteorological information to benefit marine industry, navigation, sport fishing, and the general boating public.
- The U.S. Coast Guard, because of its search and rescue and maritime law enforcement missions, and as lead agency for the reporting and monitoring of discharges of hazardous substances and oil spills and their amelioration, cooperates with the Department of Commerce by making weather observations and disseminating weather warnings and forecasts on radio broadcasts to the high seas and waters over which the United States has jurisdiction.
- The Department of Defense is responsible for providing marine meteorological information to its forces as well as for cooperatively providing ship and coastal observational data to other agencies for marine services use.

Marine meteorological observations include those from the cooperative merchant ship program, the tide and wave gage network, environmental data buoys, offshore oil platforms, satellites, and about 200 cooperative marine reporting stations along the U.S. coastline. Practically all these coastal stations are operated by the Coast Guard and provide 3-hourly observations upon request.

Environmental data buoys, funded and operated by NOAA, are used to obtain observations from offshore areas. The data are relayed to shore by satellite. The Coast Guard, through a cooperative agreement with NOAA, places the buoys on station and removes them for overhaul and maintenance purposes. Additionally, NOAA has wind speed sensors on eight large Coast Guard navigational buoys. Data from these are relayed to shore via Coast Guard communications.

Forty-one naval vessels have sophisticated equipment for detailed surface observations; 31 are equipped to make upper air observations. Twenty Coast Guard cutters are also equipped with balloon inflation shelters for making upper air observations. These observations are made available to other Federal agencies through routine collection and exchange of data. Improvements are needed in data handling, along with meteorological personnel on more ships, and better marine forecast techniques.

The Department of Commerce supplements the analysis and forecasting functions of the Basic Meteorological Service with specialized marine support operations at a number of its Weather Service Forecast Offices (WSFOs). WSFO San Francisco is one example of locations that disseminate marine environmental information in cooperation with the Coast Guard. Weather and sea forecasts and storm warnings are provided by radiofacsimile, voice, and radio telegraphy from the Coast Guard Communications Station at Point Reyes, California. WSFOs Honolulu, San Francisco, Washington, and Miami provide high-seas marine information for the North Pacific and the western North Atlantic. WSFO Honolulu also provides services for part of the South Pacific. Within these areas the United States is responsible for shipping forecasts and storm warnings under the Safety of Life at Sea Convention in accordance with agreements with the World Meteorological Organization. In the extreme western North Pacific, the Department of Defense continues to provide services required by WMO agreements. In Alaska, NWS operates five coastal radio stations to broadcast marine warnings and forecasts, and to expedite the receipt of marine data. WSFO Anchorage, Alaska, provides marine support in the Gulf of Alaska and the Bering Sea. WSFO Fairbanks provides marine weather and ice forecasts for the Chukchi and Beaufort Seas. WSO Valdez has been augmented to provide 24-hour service at the trans-Alaska pipeline terminal where supertankers load and begin their voyage down the stormy Prince William Sound and across the Gulf of Alaska to U.S. ports. At WSFO Seattle, NOAA has begun a development program directed toward improving marine environmental support activities.

In other areas, such as coastal and offshore waters, 19 WSFOs issue marine advisories and warnings. The Great Lakes weather and ice service program, provided by five WSFOs, has been substantially aided by resources of the Great Lakes and St. Lawrence Seaway Navigation Season Extension Demonstration Program, which is managed by the Department of Defense's Corps of Engineers. NWS has added an ice forecaster position to the staff at WSFO Detroit to support this important service.

Four Fleet Weather Centrals and one Fleet Weather Facility supplement the output of the Navy's Fleet Numerical Weather Central (FNWC) and NOAA's National Meteorological Center by preparing detailed analyses, forecasts, and warnings for their assigned areas of responsibility. In addition, FNWC and one of the Fleet Weather Centrals provide optimum-track ship-routing services to naval vessels and commercial ships operating under Department of Defense contract. The Fleet Weather Facility

Table 11—Marine Meteorological Service costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 78	FY 79	FY 78	FY 79	FY 78	FY 79
Commerce	2,308	3,107	565	565	2,873	3,672
Defense:						
Navy	9,677	9,934	2,520	3,216	12,197	13,150
Transportation:						
Coast Guard	771	881	—	—	771	881
Total	12,756	13,922	3,085	3,781	15,841	17,703

provides ice forecasts and warnings for the Arctic and Antarctic areas.

Dissemination channels provided by the Department of Commerce for weather information and warnings in coastal areas and the Great Lakes include a Great Lakes teletypewriter system, NOAA Weather Radio broadcasts, messages over the NOAA Weather Wire Service, and recorded telephone forecasts.

A special service for high-seas shipping is provided by NOAA in cooperation with the National Bureau of Standards, using the time-signal broadcast facilities of WWV (Colorado) and WWVH (Hawaii). It consists of three brief 45-second broadcasts each hour, giving information on major storms in the North Atlantic and the North and South Pacific. Facsimile radio broadcasts from Coast Guard and Department of Defense are available to ships. Department of Defense naval broadcasts—voice and facsimile—primarily support naval forces and are subject to changes in schedule and content without notice.

Marine users rely on the various communications systems or on the Coastal Warning System for their information. The latter system is a cooperative network of about 300 visual (flag and light) signals at prominent locations along the coasts, Great Lakes, and inland waterways to advise marine interests when advisories or warnings are in effect. The U.S. Coast Guard operates about one-third of these displays. Non-Federal interests operate the rest. This system is being phased out in favor of the NOAA Weather Radio continuous weather broadcast system, which offers up-to-date information. The Navy has 44 weather offices at shore stations and 41 weather offices aboard ship that are equipped to provide marine briefing services in support of Naval operations. Not all of the offices aboard ship are staffed. Support of warning services on the West and Gulf Coasts are provided in part by a dedicated Marine circuit. Stations are a mix of commercial marine radio, Coast Guard, and NOAA, functioning both as points for gathering reports from ships and disseminating warnings and forecasts for shipping. Plans to expand along the entire West Coast including Alaska are in progress.

Table 11 lists the costs of the Marine Meteorological Service, by agency, for fiscal years 1978 and 1979.

Operational Program for Fiscal Year 1979

The Department of Commerce plans an increase of $625,000 for fiscal 1979. Of this amount, $200,000 would be used to make technical studies and to prepare a plan for the development of an ocean climate monitoring system. The system is expected to use suitable existing platform types such as satellites, regularly scheduled commercial ships, and ocean data buoys to gather essential oceanic measurements required for climatic research and prediction. The other $425,000 is required to procure equipment for an expanded observational program on the Great Lakes that will give NWS more specific environmental information to aid in providing forecast and warning services to a wide variety of Great Lakes marine activities.

The Department of Defense (Navy) is requesting a net increase of $257,000 for fiscal 1979. The most significant item of the program changes is for procurement of shipboard equipment for aircraft carriers that will read out Defense Meteorological Satellite Program data.

Research Program for Fiscal Year 1979

The Department of Commerce is continuing to develop and improve marine environmental forecast methods for oceanic, coastal, and Great Lakes areas. The research and development is on tropical and extratropical storm surges, coastal winds, beach erosion, oil spill trajectories, and wave conditions.

In the oceanic area during fiscal 1979, the automated forecasting of ocean wave conditions will be improved by more accurate calculations of swell period. Under the interagency funding agreement between NOAA and the Environmental Protection Agency, NWS will continue numerical model development for predicting movement and concentration of petroleum following an oil spill. An oil spill trajectory model will be implemented.

Procurement of a prototype Shipboard Environmental data Acquisition System (SEAS) will take place in fiscal 1979. SEAS will provide automatic sensing and preprocessing of air temperature, pressure, and winds together with sea-surface temperature and salinity. The parameters will automatically be transmitted to NWS via GOES satellite from ships on the high seas. SEAS will provide forecasters with needed data for monitoring ocean conditions and severe weather affecting commercial fishing and all shipping traffic, particularly tankers. It should also make forecasting for U.S. land areas more accurate.

Research and development in the coastal area will result in improved hurricane storm surge programs which include a variable grid as a function of shelf bathymetry. A hurricane storm surge forecast model will be put into operational use for the New Orleans area. Sea-air temperature difference will be considered as a predictor of extratropical strom surges. The coastal wind technique will be expanded to include additional

locations on the East, West, Gulf of Mexico, and Alaska Coasts. The beach erosion technique will be modified to include wave refraction as a predictor.

The work on automated forecast techniques for the Great Lakes will continue. The Great Lakes wave forecast program will include additional forecast points. Fetch length reduction due to the presence of lake ice will be considered. The forecasts of Great Lakes water levels will be verified.

The Wave Propagation Laboratory will continue research to establish the capabilities and limitations of HF sky wave radar for monitoring sea state out to 3,000 km distance. The utility of the smaller coastal radar system will be demonstrated for a variety of coastal applications by mapping surface current fields and measuring the wave height directional spectrum. New techniques will be developed and old ones expanded for interpreting orbiting microwave short-pulse altimeter and synthetic aperture radar output in terms of sea state.

Research, development, test, and evaluation on buoy components and systems will continue to focus on the problems of withstanding the severe ocean environment. The buoy program of about $8 million in base funding is not reflected here, but is described and accounted for in the *Federal Plan for Marine Environmental Prediction* (revised annually).

The Navy is continuing research on large- and small-scale severe weather phenomena such as tropical cyclones and thunderstorms, through field experiments, laboratory studies, and numerical modeling. Analysis and prediction models and techniques are being developed for providing a global, automated prediction system. The system would collect, process, disseminate, and display environmental information for use in problems unique to military operations on a near real-time basis. Techniques are being developed for the test, evaluation, and use of SEASAT-A data when they become available.

Agriculture and Forestry Meteorological Services

Description

These services are becoming more vital to the Nation's welfare and economy with the increased need to maintain and protect our food and forest resources. The Departments of Commerce and Agriculture share responsibility for providing the Agriculture Meteorological Service that includes specialized observations, forecasts, advisories, warnings, assessments of the impact of weather and climate upon agricultural production, and supporting research directed toward the needs of agricultural interests.

The Department of Commerce plans and performs the service, while the Department of Agriculture carries out supporting research, assists in planning, and cooperates in observing, communicating, and distributing weather information.

The present agricultural weather service provides specialized local observations for farming areas, technical studies in weather-crop relationships, extension advisory services, and crop-specific, site-specific weather forecasts tailored to local farming operations. In many cases, observations are made on a cooperative basis between the Department of Commerce and other Federal and State agencies or private interests. Observers for Federal and State agencies at agricultural experiment stations, colleges, and universities obtain detailed small-scale meteorological data for studying agriculture-weather relationships.

Forecasts for agricultural users—ranging from a short-period forecast that affects planting, harvesting, crop dusting, and spraying to a 30-day and seasonal outlook for general agricultural planning—are prepared at NOAA Weather Service Forecast Offices (WSFOs). Interpretive and extension services are provided by advisory agricultural meteorologists from five Weather Service Offices and four Environmental Studies Service Centers. A service for livestock producers in Wyoming and North and South Dakota makes recorded forecasts and warnings continuously available by telephone from mid-October to mid-May. Similar weather services for fruit and vegetable growers are available in New Jersey and Michigan.

A special fruit-frost service is concentrated in the western States, Wisconsin, and Florida. This service has been integrated into the Agriculture Meteorological Service in western lower Michigan, the lower Rio Grande Valley, New Jersey, Utah, and in West Virginia. The service provides warnings of low temperatures for specific stations along with an outlook for the next three to five nights; an advisory service to growers on how to prevent frost and freezing temperature damage; annual reports on the general character of each season with respect to crop-weather relationships; temperature surveys in agricultural areas; and studies of temperature and crop relationships.

Specialists from NASA, NESS, NWS, and the University of Florida have cooperated on a test to use satellite thermal infrared data in the operational frost warning service provided by the WSO at Ruskin, Fla. Results of the test have been encouraging, and plans are underway to investigate the use of a more comprehensive data base and computer models for operational testing.

Agricultural forecasts, warnings, and advisories are disseminated to the State Extension Services, directly to users, and to the mass media over the NOAA Weather Wire Service, NOAA Weather Radio, telephone, and the press wire services.

The Extension Service and NWS are cooperating on a pilot agricultural weather program in parts of seven States to obtain localized weather observations and interpret them for day-to-day agricultural production decisions. Five additional States will be included in this program before the 1978 growing season begins.

The Department of Commerce, in cooperation with the Department of Agriculture, participates in publishing the *Weekly Weather and Crop Bulletin*. This publication includes crop condition reports along with national and worldwide crop summaries and has about 5,000 subscribers across the country. Continuing extreme drought conditions in the middle and far western States are adversely affecting the Nation's agricultural products and emphasizing the importance of current and reliable weather information for agriculture.

In an effort to improve further the Agriculture Meteorological Service, existing resources are being concentrated into the new Environmental Studies Service Centers. The first was established at Auburn, Ala., to serve Alabama, Florida and Georgia; the second, located at Stoneville, Miss., serves Arkansas, Louisiana, Mississippi, and Tennessee; the third to serve New Mexico, Oklahoma, and Texas from a location at College Station, Tex.; and the fourth to serve Illinois, Indiana, Kentucky, Michigan and Ohio from a location at Lafayette, Ind.

The Centers provide:

- Agricultural weather summaries and advisories
- Technical studies relating weather to agriculture
- Consulting services for agricultural research efforts
- Liaison services with agricultural organizations and users.

A further effort to improve this service has been made through agreements between NOAA and the States of Iowa, Kansas, Minnesota, Nebraska, and South Dakota. These agreements provide for current exchanges of information between the respective WSFOs and the State Agriculture Extension Services. On the basis of this guidance the WSFOs issue forecasts three times a week directed to current agricultural needs.

The agricultural meteorological service is not yet fully available for all major crop belts. As a result, there is a need for improving organizational support for this service. In addition, a need exists for continuing research in such areas as weather-crop relationships and the effect of climate on crops and insects. An updated *Federal Plan for a National Agricultural Weather Service* will be published in 1978.

Federal, State, and local agencies charged with protection and maintenance of the Nation's forests depend on reliable meteorological data and forecasts provided by the Department of Commerce. A specialized national plan is being developed that describes in more detail the services available to forestry interests.

The Forest Service of the Department of Agriculture and the Bureau of Land Management of the Department of Interior, along with State forest agencies contribute to the Forestry Meteorological Service by supplying observations to monitor fire weather conditions for some 2,000 locations scattered through State and national forests and rangelands of the United States. This program consists of daily measurements of temperature, precipitation, wind, humidity, and fuel moisture. These data are archived in computer-accessible format. The Forest Service also carries on forestry research that supports this service.

Within the framework of broad-scale guidance produced by the National Meteorological Center, specialized forecasts and warnings for use by fire control agencies are provided by 50 selected NWS weather offices. These WSFOs and WSOs are responsible for specialized forecast, advisory, and warning services to forestry and rangeland fire control interests. These services include 5-day outlooks, 36- to 48-hour general forecasts of winds, temperature, rainfall, humidity, and fuel moisture on a twice per day basis in most areas during the forest fire season. Forecasts are issued, as required, during a fire. In addition, these offices provide specialized forecast and advisory services for a host of wildland management and silviculture activities.

The National Weather Service and the Forest Service of the Department of Agriculture are jointly supporting an experimental Forestry Weather Interpretation Unit in Macon, Ga. This unit develops and provides specialized services that help forestry interests make better use of NWS forecasts. The unit also develops procedures and products that help NWS forecast offices improve their forecast, advisory, and warning services to forestry interests.

Twenty camper-type mobile units and two trailer-type air portable mobile units, manned by fire weather meteorologists, are available in the western United States for dispatch to major forest fires. Contact with the home station is maintained by two-way radio and radiofacsimile for relay of appropriate meteorological data. Fire control interests receive immediate forecasts and advisories from the unit on the scene of action.

NOAA also supports smoke management programs for control of prescribed burning operations for the removal of forestry and agricultural wastes. Forecasts are issued to help Federal and State authorities determine when, where, and how much debris to burn without degrading the air quality.

Table 12 lists the costs of the Agriculture and Forestry Meteorological Services, by agency, for fiscal years 1978 and 1979.

Operational Program for Fiscal Year 1979

The Department of Agriculture plans an increase of $737,000 for fiscal 1979 to expand the pilot agricultural weather program in several States where localized weather observations are used to contribute to agricultural production decisions, particularly pest management.

Research Program for Fiscal Year 1979

The supporting research program of the Department of Agriculture will emphasize the relationships of weather and climate to plants, animals, and the environment. Specific studies are being made on how climatic factors affect various insect species, including development and behavior, and on better uses of beneficial insects. Research is seeking to determine the relationship between climate and such factors as crop hardiness, quality, productiveness, and drought resistance. Methods are being developed for the establishment of windbreaks and for the determination of their effect on air, soil, water, and snow movement. The Department of Agriculture is directing a national research program on plant disease epidemiology and forecasting in which extensive use is made of micrometeorological data observed at plant level. A pilot program is now being developed to monitor moisture levels in representative soils under alternative crop and management systems. The objective here is to predict soil behavior (yield, erodibility, and other behaviorial aspects) under varying conditions of climate, land use, and weather.

Studies are being performed to determine the action of air pollutants on plants and methods of controlling the damage. The Department of Agriculture is cooperating with State and Federal agencies and universities to establish a nationwide program for monitoring deposits of atmospheric pollutants to determine their extent and effects on agriculture and natural ecosystems.

Investigations will determine the potential economic effects of weather on crop production, both domestic and foreign. One aspect of these studies concerns the development of models relating various weather parameters to crop yields.

Table 12—Agriculture and Forestry Meteorological Services costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 78	FY 79	FY 78	FY 79	FY 78	FY 79
Agriculture	370	1,107	2,544	2,713	2,914	3,820
Commerce	4,366	4,714	40	40	4,406	4,754
Total	4,736	5,821	2,584	2,753	7,320	8,574

A worldwide meteorological data base is being compiled, and research is in progress to determine crop-yield patterns associated with various meteorological factors. Department specialists are consulting with climatologists to define the probabilities of climate changes, and their resultant effects on U.S. and world food production.

The Department of Agriculture recently initiated a national research program directed to determining crop response to climatic factors. Specifically, better parameters for predicting the response of wheat, grain sorghum, soybeans, and cotton to soil moisture, solar radiation, ambient and soil temperature, and precipitation will be obtained. Of particular interest is the crop response at different phenological stages.

In the area of mountain meteorology, the Department of Agriculture is studying the interaction between mountainous terrain and the atmosphere in relation to such problems as precipitation, temperature specification, and wind flow. A significant part of this research will be concerned with the definition of mesoscale variation. NWS and the Southeast Forest and Range Experiment Station of the Forest Service have a joint experiment to develop, test, and demonstrate a new format for fire weather service in the South. Research is being conducted on wind regimes characteristic of mountain terrain. Special emphasis is given to modeling Santa Ana and terrain-induced flows. Flow patterns responsible for the transport and dispersion of smoke plumes from forest fires are also modeled.

The NWS Techniques Development Laboratory will continue its work on automated forecast techniques for weather elements important to agricultural interests. Statistical prediction equations for dew, frost, precipitation, and soil temperature have been developed for several locations in Indiana and Michigan. Equations to predict air temperature, daily insolation, and relative humidity are being derived. Forecasts as far as 5 days in advance, based primarily on output from the Primitive Equation model, will be generated routinely for use as guidance by NWS forecasters in Indiana and Michigan. This project is serving as a prototype for expansion to many other States where agriculture is a major industry.

General Military Meteorological Service

Description

The Department of Defense requires worldwide meteorological services to support specific military operational and planning activities. The General Military Meteorological Service provides military users with support not available from the Basic Meteorological Service or from other Specialized Meteorological Services. Support for explicit users, such as aviation, marine, and space operations, is covered in the sections on the relevant Specialized Meteorological Service.

Military user groups require meteorological information directed to the needs of:

- Weapon systems being developed or employed
- Command and control systems
- Army and Navy firing units
- Research, development, test, and evaluation
- Training and deployment of military forces
- Contingency operations

To provide these special meteorological services, the Department of Defense maintains analysis and forecasting facilities in the United States and abroad, including the Air Force Global Weather Central at Offutt AFB, Nebr., the Navy Fleet Numerical Weather Central at Monterey, Calif., plus forecast centers and tactical forecast units in Europe, the Pacific, and the Far East. Specialized centers—such as the Air Force Environmental Technical Applications Center at Scott AFB, Ill., and the Joint Typhoon Warning Center at Guam—also fulfill unique military meteorological requirements. Similarly, Department of Defense observation facilities are operated to obtain data in direct support of military operations. Military communications networks are

Continental U.S. Meteorological Data System terminals at Carswell AFB, Texas prior to their official dedication. Shown are the CRT display, teletype keyboard transmitter, and paper copy printer.

maintained to collect and exchange observations and to disseminate forecasts.

The Navy's Naval Environmental Display Station (NEDS) Program has begun to reach the field, and active development continues. The first NEDS-1 unit was installed at Fleet Weather Central Pearl Harbor in June 1977, initiating a new era of environmental support. NEDS devices are being designed and procured for support of shore stations and for shipboard use. NEDS is to become the Navy's primary medium for transmission, receipt, storage, manipulation, and display of graphic, alphanumeric, and satellite data. NEDS includes multicolored visual displays of environmental parameters of tactical significance to the operator. NEDS is designed to be compatible with both low- and high-speed landline communications, and with present and future satellite communication systems. Inter-agency coordination helps to ensure that automated systems such as NEDS and the Department of Commerce's Automation of Field Operations and Services (AFOS) will be able to communicate and exchange information.

Aerial weather reconnaissance plays a vital role in specific Department of Defense operations. Weather observations from inside tropical cyclones, along tactical deployment routes, in-flight refueling and missile recovery areas are some of the locations where essential weather data are obtained by reconnaissance aircraft.

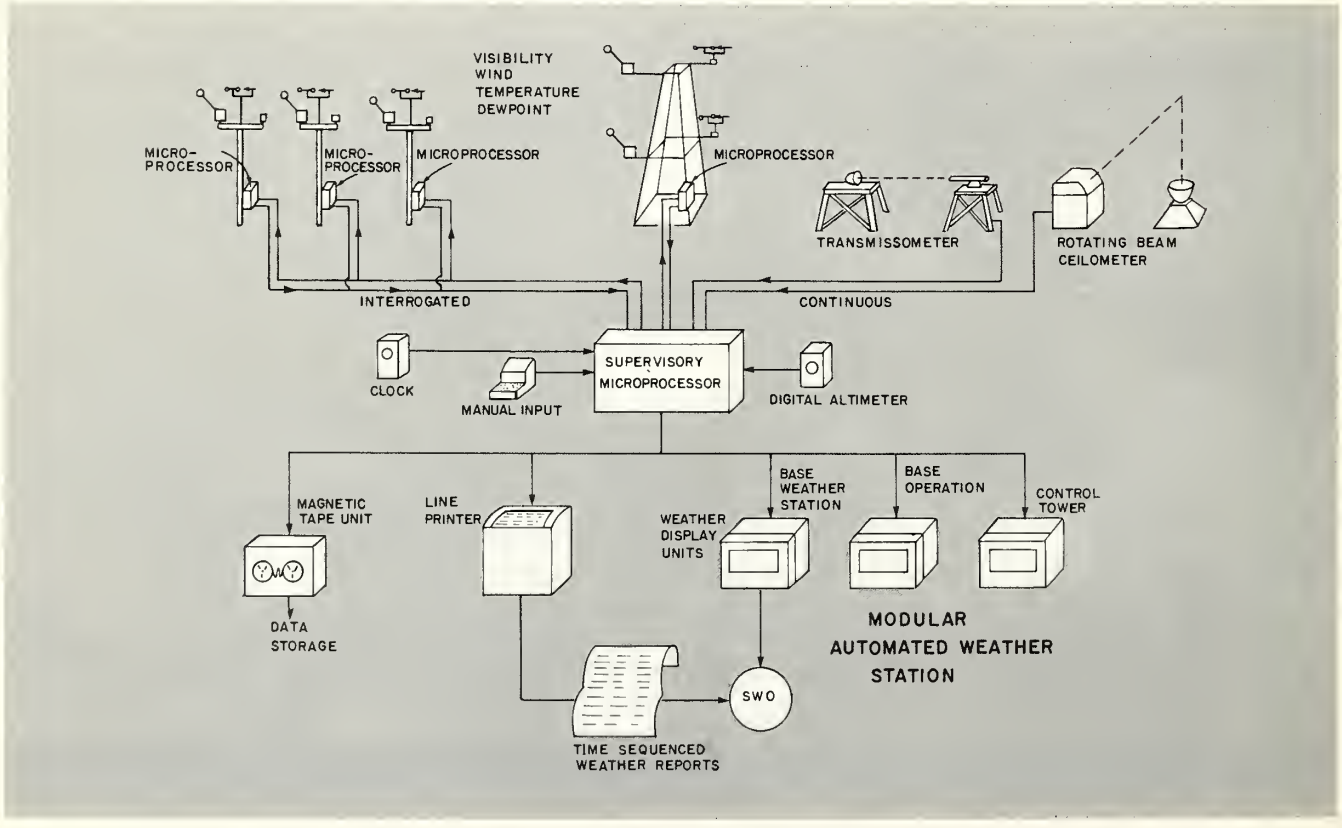
Storm detection radars are selectively used by the military meteorological services to provide an essential capability to detect severe, hazardous weather affecting military activities.

In support of tactical operations, Department of Defense has developed a series of air-transportable van complexes and is capable of deploying mobile tactical weather stations, radiosonde teams, weather radars, and meteorological satellite direct readout equipment.

The Defense Meteorological Satellite Program (DMSP) was designed and developed under a total systems concept to provide specialized meteorological data required by the Department of Defense. Sensors, communications, and ground processing facilities were developed with the primary objective of providing maximum responsiveness to the military decision maker. DMSP provides—at four observation times per day—visual and IR images of the entire globe plus temperature and moisture profile soundings, auroral electron count, and other specialized meteorological data to the Air Force Global Weather Central, Offutt AFB, Nebr. It also supplies direct real-time readout of regional visual and IR data to selected military locations around the world.

DMSP routinely uses two polar-orbiting satellites, each in an approximate 830-km polar Sun-synchronous orbit with a period of 101 minutes. One satellite has an early morning local ascending Equator-crossing time, and the other has a near-noon ascending Equator-crossing time.

With the launching in September 1976 of a new series spacecraft (Block 5D), DMSP entered into a new era of satellite technology. Subsequently, the DMSP Block 5C program was terminated during December 1977. DMSP Block 5D satel-



Modular Automated Weather System being developed by the Air Force Geophysics Laboratory. The system is designed to provide complete automation of the observation, dissemination, display, and short range forecasting of airfield weather information.

lites use scanning radiometers operating in the visual and infrared (IR) wavelengths.

The visual sensors detect the brightness of reflected solar illumination from 0.4 to 1.1 micrometers. The IR sensors measure emitted radiation from 8 to 13 micrometers. The IR products are images of the Earth and its atmosphere and are representative of their temperatures. Both IR and visual images are obtained. The spectral band width of the visual sensors was selected to optimize distinction among clouds, ground, and water. Electronic circuitry in the sensor converts the sensed IR energy directly into equivalent blackbody temperature, making temperature the directly displayed parameter. The sensitivity of the 2.8-km visual channel covers seven orders of magnitude; this enables it to provide useful meteorological information from full daylight over highly reflected scenes to an illumination level roughly equivalent to the light of the half Moon.

The new DMSP spacecraft series (Block 5D) also incorporates selective redundancy and other reliability improvements to achieve longer operational life. It uses both stellar and inertial reference, together with on-board processors, to maintain stability and pointing accouracy significantly better than earlier DMSP satellites. The Block 5D primary sensor system is an Operational Linescan System (OLS). This sensor system produces visual and infrared imagery while maintaining data quality, bounding data storage, and relay impacts. OLS is a digital system with increased on-board data processing and storage. The sensor segment was developed to format and store data from a number of anticipated special sensor systems. The infrared and visual imagery are obtained at a near-constant cross-track resolution of 0.5 km (called fine data) and in a smoothed form at 2.8-km resolution.

DMSP communications and ground processing systems are designed to produce usable products within 5 minutes after the data stream terminates. For direct readout, this means a data age of 5 to 20 minutes when ready for application to operational decisions. The central processing facilities at the Air Force Global Weather Central and Navy Fleet Numerical Weather Central are linked to the DMSP readout facilities by a real-time commercial satellite link. This allows for real-time recovery of (stored) recorded data such that the only timing increment added to the processing time is the transit time of the DMSP satellite from the observation scene to that part of the orbit where data can be acquired by the ground station. The data display units at AFGWC and other direct readout ground receiving stations were designed with the following features to facilitate data interpretation:

- Orbital Normalization—Compensates for differences in altitude and attitude.
- Equal Area Projection—Foreshortening at the edges is removed.
- Large-Scale Transparency—The nominal scale is switch selectable at either 1:3.75 million, 1:7.5, or 1:15 million.
- Enhancement Options (Visual data)—Variations in solar illumination are compensated for. The visual imagery displayed can be improved in the low, high, or a low-high mode. Navy direct readout ground stations also can provide logarithmic enhancement, which provides increased contrast in areas of low reflectivity with a sacrifice of contrast in areas of high reflectivity. It is best used to examine anomalous gray shades and to provide special enhancements whereby the system operator can select the range of gray shades to be enhanced.
- Thresholding and Scale Expansion (IR Data)—Navy direct readout ground stations have an additional capability that enables the system operator to produce any enhancement output desired.

The Air Force and Navy shore-based systems for direct, local readout are contained in a self-enclosed unit, including antenna, which is air transportable, making overseas deployment to full-scale operation a matter of hours. Additionally, the Navy has developed a similar local readout system for shipboard use. The centralized processing facility at AFGWC has the capability to:

- Display high-quality imagery for manual use.
- Input the raw DMSP data stream directly into computers where it is converted into cloud parameters and collated with conventional meteorological data to produce a comprehensive numerical cloud analysis.

The centralized processing facility at the Navy Fleet Numerical Weather Central will have, as a portion of the initial operating capability on June 1, 1978, the capability to: Input the raw DMSP data stream directly into computers, map these data into a global satellite data base at the full 2.8-km resolution, and extract for local display or transmission to a remote field activity, any 512 by 512 picture element window from the data base.

NOAA's Environmental Data Service archives the DMSP data. The University of Wisconsin's Space Science and Engineering Center is their agent for archiving imagery. The National Climatic Center is their agent for archiving data from vertical profiles of temperature and humidity. Table 13 lists the cost of General Military Meteorological Service for fiscal 1978 and 1979.

Table 13—General Military Meteorological Service costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 78	FY 79	FY 78	FY 79	FY 78	FY 79
Defense:						
Air Force	29,494	30,161	7,361	7,250	36,855	37,411
Army	7,808	6,102	13,738	21,107	21,546	27,209
Navy	11,113	11,129	5,680	6,250	16,793	17,379
TOTAL	48,415	47,392	26,779	34,607	75,194	81,999

Operational Program for Fiscal Year 1979

The Department of Defense is projecting a net decrease of $1,023,000 in spending for General Military Meteorological Service in fiscal 1979. The Army's decrease of $1,706,000 is due to reductions in manning, authorized meteorological sections, and training. The Air Force plans a total net program increase of $4,764,000 of which 14 percent or $666,000 is attributed to General Military Meteorological Service. Significant changes include $4.8 million for costs related to training, ground meteorological equipment, and management; $1.4 million in communications costs principally for purchase of leased automation equipment; and $0.9 million for weather reconnaissance. There will be offsetting decreases of $2 million in the meteorological satellite program and $1.98 million in costs of automation, personnel, and equipment for operations supporting analysis and forecasting.

Research Program for Fiscal Year 1979

Some of the Department's research programs have been categorized and discussed under previous subsections of the Plan as research directed toward improvements in a specific Service. These are also considered as research in support of the General Military Meteorological Service, because they are directed toward improvements in meteorological support to the overall Department of Defense mission.

The research program in the Air Force has as its goal better methods of observing, processing, displaying, and, in some cases, modifying meteorological elements to promote safe and efficient operations.

The Air Force is improving its ability to detect and identify atmospheric hazards to air and ground forces. One approach is through improvements in weather radar technology in such areas as the measurement, processing, display, and automatic interpretation of data from ground-based radars. In FY 1979 and 1980, a 10-cm Doppler weather radar with capabilities for self calibration, frequency diversity, and data quality assurance will be developed and tested. A parallel effort will involve incorporation of a network of transducers and circuit monitors at key locations in the radar system and tied into a central processor to provide an automated indication of system performance. Attempts will be made to develop and test techniques for refining predictions of snowfall rate for the 0- to 2-hour time frame based on radar reflectivity measurements. The results of the Joint Agency Doppler Technology Tests will be analyzed by early in the 1979 fiscal year and will support the Air Force's attempt to develop diagnostic weather radar techniques for the operational detection of significant features of storms.

The TMQ-22 Tactical Meteorological Kit is used in providing tactical weather observations.

Another program is directed toward developing techniques for the efficient use of meteorological satellite data in the preparation of automated 0- to 6-hour forecasts of local weather conditions. In the 1979 and 1980 fiscal years, initial results of a program to provide objective specification of cloud cover and precipitation from satellite data alone are expected to be ready for testing, as will techniques for generating improved nephanalyses through the use of multispectral satellite data. In contemplated DMSP R&D efforts, the spectral interval of the infrared channel may be reduced from 8 to 13 micrometers, to 10.5 to 12.5 micrometers and the temperature range expanded from 210 to 310K, to 190 to 310K.

The objectives in a realted program are to develop and evaluate:

- Improved sensor, processor, and display components for automated weather observing systems other than radar systems, and
- Techniques for automated forecasts of operationally significant local weather events.

During fiscal 1979 and 1980, additional features to be added to the AFGL-developed Modular Automated Weather System (MAWS) will include automation of ceiling and cloud cover specification, slant visual range, causes of restricted visibility, and the type and intensity of precipitation. The Air Force also will continue efforts to develop and test a computer-based forecast system that will permit the development, in real time, of forecast algorithms needed for specific mission elements and will express the final result in terms of probabilities that the weather will be favorable for all elements of designated missions.

Another Air Force objective is to improve techniques for applying climatic information to the design, operation, and evaluation of Air Force systems. During fiscal 1979 and 1980, the spatial variability of density and temperature for altitudes up to 80 km will be determined. Efforts will be under way to extend the modeling of climatic probabilities into three-dimensional space and time. An atlas of cloud-free line-of-sight probabilities for Europe and North Africa and an atlas of instantaneous precipitation rates will be prepared.

In the area of atmospheric dynamics, the general goal is to improve the accuracy and speed of numerical weather prediction. The program will have the following objectives in fiscal 1979 and 1980:

- Devise and test methods of incorporating the effects of diffusion and dissipation in numerical weather prediction (NWP) models;
- Study how water affects the development and maintenance of atmospheric circulations;
- Compare the speed and accuracy of finite-difference and spectral methods of solution of NWP models;

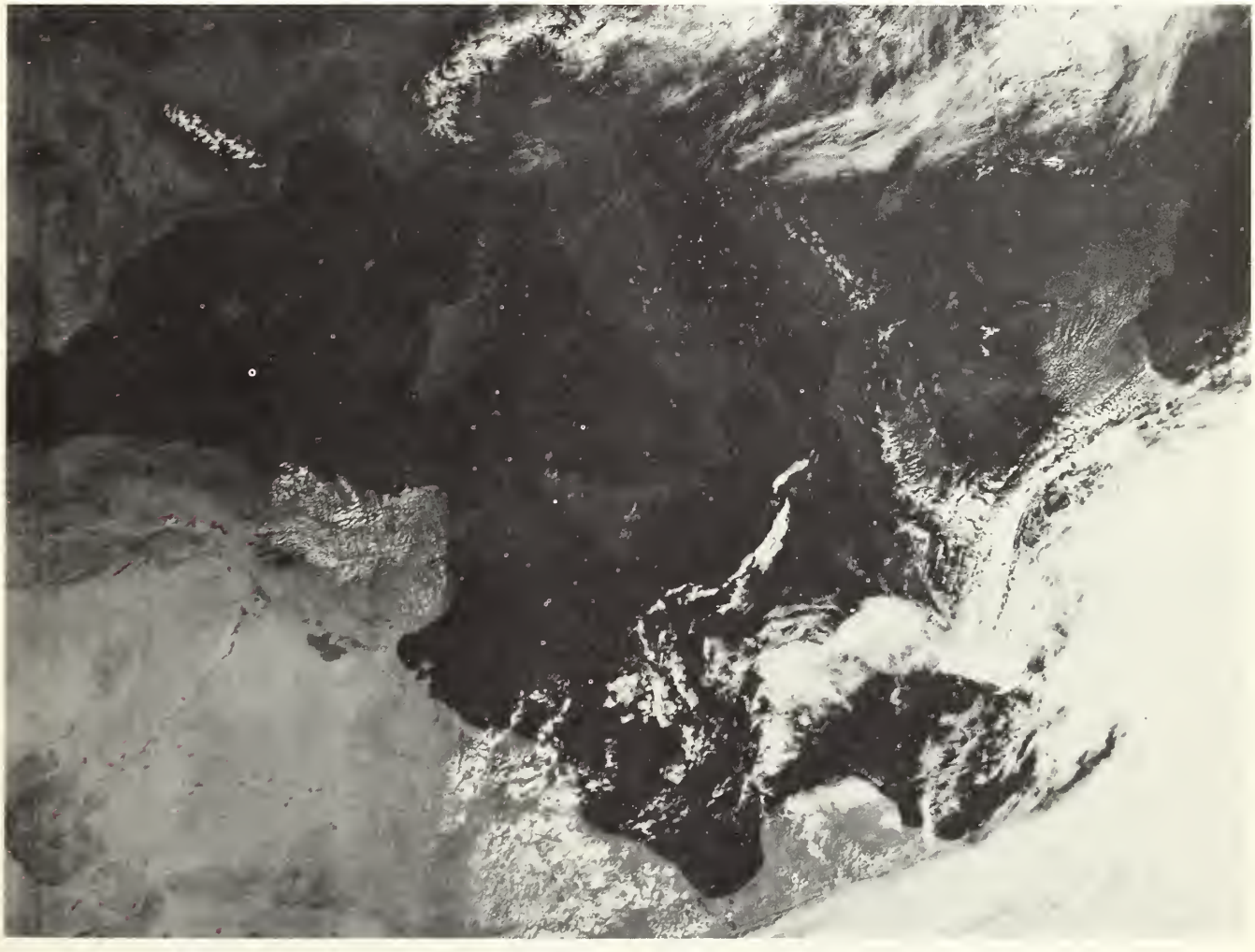
- Study the effects of small-scale processes, such as cumulus convection, on the dynamics of larger scale atmospheric motions, and devise appropriate procedures for including such effects in fine-mesh NWP models; and
- Develop a demonstration model based on an accurate and fast technique for solving the Poisson equation on a spherical surface.

A major new effort to measure hydrometeor sizes as well as their spatial distributions includes in situ measurement by instrumented aircraft. The goal is to provide engineering design and test support models as well as cloud water content parameters for use in numerical weather predictions. Statistical engineering models are needed to support studies of the erosion of missile nose cones and helicopter blades as well as to compute the attenuation of lasers and microwaves.

The Army's research program in atmospheric sciences is directed toward developing equipment and techniques that will help increase the effective use of weapon systems, conduct of field operations, and support of research, development tests, and evaluation missions. An Automatic Meteorological System currently under development will support Army battlefield intelligence functions required for integrating weather effects into tactical operational plans, smoke munition expenditure tables, CB defense, helicopter and airborne operations, and the use of terminally guided munitions. The Bulk of the Army's increase in funding for supporting research for fiscal 1979 is for an engineering development contract for additional models of the Field Artillery Meteorological Acquisition System (FAMAS). FAMAS is a highly mobile, light weight, automatic data processing, nonradiating system for meteorological data acquisition and processing that will provide the near real time upper air meteorological data required for acquisition of artillery fire control information. Mesometeorological research is underway to provide information on the properties of the atmosphere within the theoretical areas of combat. Experiments include intensive data collection from balloon-borne and airborne instruments and an automated small-scale network of observation stations. Data will be used in validating models of atmospheric processes.

Emphasis in the Navy's program is to:

- Develop sensors and data handling techniques to enable maximum use of existing, planned, and potential satellite data sources to provide adequate observations over ocean areas. This includes test, evaluation, and use of SEASAT-A data. The Navy's processing center that will use data from DMSP



Daytime view of Mediterranean at 1130L from a Block 5D satellite in the Defense Meteorological Satellite Program.

and other designated satellites is scheduled to begin operation in mid-1978.

- Develop numerical techniques to provide global forecasts up to 14 days; synoptic-scale forecasts to 3 days; and tactical-scale (local) forecasts to 24 hours.

- Develop capabilities that convert measured or forecast local environmental conditions into systems performance predictions for the operational forces.

- Study the micrometeorology and microphysics of the marine boundary layer as it relates to, and affects, propagation of electromagnetic energy through this portion of the atmosphere.

- Develop both in-situ and remote sensors to measure temperature, relative humidity, aerosols, and turbulence in the marine boundary layer.

- Develop an environment-controlled system of fuel management and flight planning to ensure optimum aircraft routing and mission performance.

Preparations are under way to participate in NASA's SEASAT-A proof-of-concept experiment. The Navy will process data from SEASAT-A, a polar-orbiting research satellite, using algorithms furnished by experimental teams designated by NASA, and will make the processed data from this experiment available to interested users. SEASAT-A is scheduled for launch in mid-1978.

The Navy will continue laboratory and field experiments in its marine fog investigations to study processes and composition of the marine boundary layer. Optical and microphysical properties of the marine aerosols are studied and models developed to relate optical parameters to basic meteorological variables for better forecasting of visibility and infrared transmission properties.

The Navy will make an engineering development evaluation of a runway weather surveillance system called Surface Condition Analyzer (SCAN) in fiscal 1978. The SCAN system, which remotely measures air temperature, surface temperature, surface conditions (clear, wet, slush, ice), and critical water depth for hydroplaning, will be evaluated to determine its usefulness as a factor in defining Naval Air Station operating conditions.

Other Specialized Meteorological Services

Description

The specialized services in this section include those required by:

- National Aeronautics and Space Administration (NASA) and Department of Defense to plan and conduct the Nation's space and missile programs.
- Federal, State, and local governmental agencies responsible for dealing with urban air pollution, and the general public concerning serious air pollution episodes.
- Department of Defense civil works projects and some research, development, test, and evaluation activities such as equipment design and testing, geophysical laboratories support, and polar research operations.
- Laboratories and test sites of the Department of Energy.

The first two of these specialized services are discussed in more detail below. Specialized services for the latter two requirements are small and relatively stable with little change planned.

To support its space operations, NASA relies heavily on the Department of Commerce through several reimbursable agreements for providing forecasting and staff support service for the:

- Space programs of the J. F. Kennedy Space Center, the Johnson Space Center, and the Marshall Space Flight Center.
- Earth-sensing unmanned satellites in the LANDSAT program of the Goddard Space Flight Center.
- Deep-space missions of the Jet Propulsion Laboratory—for which the optimum communication mode is weather dependent.
- Varied programs of the Wallops Flight Center.

Support to the NASA space centers largely involves planning and background studies for the extensive Space Shuttle program scheduled to begin late this decade. The Earth-sensing efforts require daily, near-global predictions of cloud cover. Weather satellite products are especially valuable in making such forecasts. Department of Commerce support to global space operations is provided from the World Weather Building at Camp Springs, Md. This arrangement allows for ready access both to weather analysis and forecast information and satellite data.

The Department of Defense's Air Force Eastern Test Range provides a wide range of meteorological observations needed for its missions and for the Kennedy Space Center. The Air Force also provides the forecasting services for its operations and for NASA's unmanned launches at the Kennedy Center.

The Department of Defense provides specialized meteorological services for the:

- Space and Missile Test Center at Vandenberg AFB
- Pacific Missile Range, which includes Pt. Mugu and San Nicolas Island, Calif., and Barking Sands, Hawaii.

Surface, rawinsonde, and weather radar stations on islands and ships provide support for the Atlantic and Pacific test ranges. Specialized staffs at range stations provide weather observations, forecasts, and planning studies. Observations for Department of Defense space activities are taken partly by Department of Defense personnel and partly through contracts with private industry. The observations are needed to determine the conditions that missiles and space vehicles will encounter either at launch or upon reentry into the atmosphere.

The Department of Defense range stations and the NASA Wallops Flight Center participate in the Cooperative Meteorological Rocketsonde Network through which atmospheric measurements above 30 km are collected to support missile operations, space exploration, and atmospheric research.

Meteorological support is also provided to the White Sands Missile Range, N. Mex., the Kwajalein Missile Range, and other Department of Defense research and test facilities.

In both NASA and Department of Defense programs, weather observations from local, national, and international networks are used along with weather radar, satellite, and aircraft reconnaisance data as a basis for forecasts and warnings of weather that might affect launch or recovery areas.

The Department of Commerce's responsibilities for the Air Quality Meteorological Service include the surface and upper air observations necessary to describe the weather in urban areas, air stagnation forecasts in sufficient detail to provide the basis for air pollution control decisions, and applied research to improve these observations and forecasts. Fifty-two Weather Service Forecast Offices are responsible for preparing air stagnation advisories. Fourteen of these offices are staffed with specially trained air pollution meteorologists, and six provide meteorological advisory service for smoke management. Each office offers local and State air pollution control agencies a daily outlook on the atmosphere's capability to disperse and dilute air pollutants. When restricted atmospheric dispersion is expected to persist at least 30 hours, an air stagnation advisory is issued. Advisories are updated at least every 12 hours and re-issued in 24 hours. For additional observations within urbanized areas, six cities have low-level sounding stations that provide vertical profiles of relative humidity, temperature, and winds to 3 km above the station.

Table 14—Other Specialized Meteorological Services costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting Research		Total	
	FY 78	FY 79	FY 78	FY 79	FY 78	FY 79
Commerce	1,019	1,115	—	—	1,019	1,115
Defense:						
Air Force	18,960	19,389	—	—	18,960	19,389
Army	50	1,727	—	—	50	1,727
Navy	5,646	6,398	—	—	5,646	6,398
Energy	2,612	2,758	194	212	2,806	2,970
EPA	500	500	6,450	6,450	6,950	6,950
NASA	1,483	2,011	—	—	1,483	2,011
TOTAL	30,270	33,898	6,644	6,662	36,914	40,560

The Environmental Protection Agency (EPA) is responsible for working with State and local government agencies to ensure adequate air quality meteorological support programs. Applied research and operational meteorological support to EPA is provided by the Meteorology Laboratory of NOAA's Air Resources Laboratory. Such operational support to the Office of Air and Waste Management, the EPA Regional Offices, and other EPA components includes review of the meteorological aspects of environmental impact statements, State implementation plans, application of dispersion models, and preparation of dispersion studies and evaluations.

Table 14 lists the costs of Other Specialized Meteorological Services, by agency, for fiscal 1978 and 1979.

Operational Program for Fiscal Year 1979

In the Department of Defense, the increase of $429,000 shown by the Air Force reflects 9 percent of the total Air Force program attributed to Other Specialized Meteorological Services. Discussion of the changes may be found under General Military Meteorological Service. The Army's increase of $1,677,000 includes computer programs for next generation observation equipment. The Navy's increase of $752,000 represents additional military students' salary costs attributed to training.

NASA plans an increase of $528,000 that represents costs of upcoming testing and operation in space activities. It includes atmospheric variability experiments (severe storms), shuttle flight testing, and internal support. Other agencies are maintaining essentially level funding.

Research Program for Fiscal Year 1979

EPA's applied research is in the areas of air quality dispersion model development, evaluation, verification, and application, development and application of air pollution climatology, determination and description of pollutant effects on atmospheric parameters, and determination of meteorological effects on air quality. Dispersion models for inert and reactive pollutants are under development and evaluation on all temporal and spatial scales. Planetary and urban boundary layer models are under development for use with air quality dispersion models. Development of air pollution climatology continues in cooperation with the National Climatic Center, including development of plume rise and inversion climatologies. Air quality forecasting techniques are under development using NWS/NMC forecast products. Examination of the relationship between meterology and air quality, with emphasis on ozone and sulfates, continues. The effects of air pollutants on atmospheric parameters, such as visibility and precipitation chemistry, are also under continuing investigation.

The Department of Energy's supporting research in meteorology is attempting responsive to the need to evaluate the various safety aspects of transport and storage of nuclear power systems used on space missions, and to provide radiation exposure/dose prediction capabilities in support of nuclear test activities.

Studies performed under the space nuclear power project involve the transport of materials released as a point source. These include particulates released:

- On the ground,
- As a vapor cloud in a launch-pad abort environment, and
- In the upper atmosphere during reentry abort conditions.

Studies in support of nuclear tests are made to improve the equipment and procedures for measuring, analyzing, and predicting the atmospheric processes involved in the transport of any radioactive effluents from nuclear tests. Plutonium and other radionuclide contamination in the environs are studied with special emphasis on the resuspension and transport of radioactive material by the wind.

This supporting research function also requires continuing development and implementation of radiological prediction methodologies unique to varying test configurations, release modes, and radionuclide inventories.

Appendix A

Digital Data Systems

The digital data and high-speed communications systems provide the needed collection and distribution of alphanumeric weather data and information.

Federal Aviation Administration Systems

The Modernized Weather Digital Data Communications System consolidates the circuit control and relay functions of Services A, C, and O into a single Weather Message Switching Center (WMSC) at Kansas City, Mo. These functions are performed automatically by computers combined to operate as a real-time store and forward communications switch. All Service A and C circuits extend directly into WMSC. Certain Service O circuits also extend directly into the computer switch, while others, from overseas points, pass through the Aeronautical Fixed Telecommunications Network switch, which is collocated and interconnected with WMSC. Computer-to-computer links provide for the exchange of data between WMSC and the National Meteorological Center (NMC) at Suitland and between WMSC and the Air Force Automated Weather Network switching facility at Carswell AFB, Tex.

Circuits of the Modernized Weather Digital Data Communications System are described as follows:

- Service A Area Circuits:

(a) Forty 100 word per minute (wpm) multipoint half-duplex circuits designed solely to meet the collection and routine distribution requirements of FAA. Other users may obtain receive-only drops on these circuits if their needs are compatible with those of FAA.

(b) Eighteen 100 wpm multipoint half-duplex polled circuits designed to meet the collection and routine distribution requirements of NWS. Other users may obtain receive-only drops on those circuits if their needs are compatible with NWS.

- Service A Request/Reply Circuits: Forty 100 wpm half-duplex circuits that parallel the Service A Area Circuits and enable Government flight briefing facilities to obtain information not routinely transmitted to the associated area circuit.

- Service A Low-Speed Nongovernmental Circuits: Sixteen 100 wpm multipoint circuits for distributing data to meet the requirements of nongovernment users, principally airlines whose needs are not satisfied by the area circuits.

- Service C Area Circuits: Seven 100 wpm multipoint half-duplex circuits for collecting and distributing basic meteorological data to serve both government and nongovernment users.

- Service O Area Circuits: Six 100 wpm multipoint half-duplex circuits for collecting and distributing international meteorological data to both government and nongovernment users.

- Department of Defense Circuits: Sixteen 100 wpm multipoint circuits and two 100 wpm point-to-point circuits for distributing selected civil environmental data to military customers in the continental United States.

- Weather Service Forecast Office Point-to-Point Circuits: Forty-four 100 wpm full-duplex circuits to the Weather Service Forecast Offices (WSFO) for transmission of forecast products to WMSC and receipt by WSFOs of supplementary weather data.

- Service A Point-to-Point Request/Reply Circuits: Sixty-three 100 wpm full-duplex circuits to high activity and/or flight service stations, which provide enroute flight advisory service for transmission of special products to WMSC and receipt of special weather data.

- Twenty 100 wpm half-duplex circuits with request/reply capability, to Air Route Traffic Control Centers for routine distribution of aviation weather data.

- High- and Medium-Speed Links:

2,400 bits per second (bps) full-duplex computer-to-computer circuit for exchanging Service A, C, and O data between WMSC and NMC.

1,200 bps full-duplex computer-to-computer circuit for exchanging Service A, C, and O plus military data between WMSC and the USAF Automated Weather Network terminal at Carswell AFB, Tex.

1,200 bps full-duplex Notice to Airmen circuit between WMSC and the National Flight Data Center.

1,200 bps full-duplex point-to-point circuit for distributing Service A, C, and O data to the FAA Central Flow Control Facility.

2,400 bps full-duplex computer-to-computer circuit for exchanging Service A, C, and O data between the Aeronautical Fixed Telecommunications Network and WMSC.

2,400 bps full-duplex computer-to-computer circuit for distributing Service A, C, and O data to the NWS National Severe Storms Forecast Center.

2,400 bps full-duplex computer-to-computer circuit for exchanging Service A data between the Aviation Weather and NOTAM System and WMSC.

2,400 bps full-duplex computer-to-computer circuit for use in developing pilot self-briefing techniques.

2,400 bps multipoint circuit for distributing Service A, C, and O data to very high volume airline and other nongovernment users whose needs cannot be satisfied by low-speed circuits.

1,200 bps multipoint circuit for distributing Service A, C, and O data to very high volume airline and other nongovernment users whose needs cannot be satisfied by low-speed circuits.

Five 1,200 bps point-to-point circuits are in use for testing devices for future application in Flight Service Stations.

Department of Commerce Systems

Radar Report and Warning Coordination (RAWARC) Teletypewriter Network—This network is used to collect and distribute radar reports and storm warning information. RAWARC is composed of five circuits terminating at the Radar Analysis and Development Unit in Kansas City as well as at the automated relay center in Suitland, Md. Traffic on RAWARC is basically unscheduled and is handled according to a priority system. The only regularly scheduled operation on RAWARC is an hourly collection of radar reports that is relayed to other circuits as required.

NOAA Weather Wire Service—See page 12.

Special Communications Links Between Guidance Centers—A high-speed alphanumeric and graphic computer link has been established between the National Meteorological Center/National Environmental Satellite Service and the National Hurricane Center to allow exchange of aircraft reconnaissance data, satellite data, and other processed information. A similar link has been established between the National Meteorological Center/National Environmental Satellite Service and the National Severe Storms Forecast Center.

International Circuits—In addition to the Service O circuits funded by FAA, the Department of Commerce has 11 international circuits to exchange meteorological data among the United States and Argentina, Bahamas, Brazil, Canada, the Central American nations, Cuba, Great Britain, Jamaica, Japan, Mexico, Russia, and South Africa. These include a low-speed circuit between Washington and Bahamas, Washington and Buenos Aires, Washington and Jamaica, and Washington and Mexico; a Washington-Central American loop; a Washington-Moscow circuit for exchange of satellite information; a Washington-Toronto high-speed circuit; a Washington-South Africa high-speed trunk curcuit; and three other circuits—Washington-Bracknell (England), Washington-Tokyo, and Washington-Brasilia—that are part of the World Weather Watch main trunk circuit. The Washington-Bracknell circuit is also used to exchange facsimile charts.

Radio Circuits—Weather messages and observations prepared aboard ships at sea are transmitted by radio, primarily by Morse code, to shore-based radio stations and are relayed to NMC. The Teletypewriter Exchange Service, international communications carrier facilities, and Coast Guard circuits are used for the relays. More than 1,000 observations are automatically processed, separated geographically, and consolidated into bulletins each day for distribution on domestic and international meteorological communications facilities.

NESS Satellite Communications System—The National Environmental Satellite Service (NESS) telecommunications system (SATCOM) is divided into two discrete subsystems, one serving the NOAA polar-orbiting satellites (NOAA) and the second serving the geostationary satellites (GOES) and the associated GOES Satellite Field Services Stations (SFSS). The major elements in the polar-orbiting satellite subsystem are the Command and Data Acquisition Stations (CDAS) at Wallops Station, Va., and Gilmore Creek, Alaska, and the Satellite Operations Control Center in Suitland, Md. The Synchronous satellite subsystem connects Wallops Station, Va., with the Central Data Distribution Facility (CDDF) at Camp Springs, Md.

CDDF is connected in turn with the Gilmore Creek CDAS with five SFSSs located in Washington, D.C., Miami, Kansas City, San Francisco, and Honolulu, and with the NWS San Juan, P.R. WSFO. The Gilmore Creek CDAS relays satellite data by two Satellite Distribution Circuits to the Anchorage SFSS and the NWS WSFOs at Anchorage, Fairbanks, and Juneau. To support the new TIROS N series operational satellite system, new communication links were added in fiscal 1978. By the end of fiscal 1979, SATCOM will consist of the following high- and medium-speed links:

- 12-megahertz full-duplex terrestrial microwave circuits between the World Weather Building and the Federal Office Building 4, at Suitland for relay of GOES data.
- 2,400-hertz full-duplex circuits from computer output at CDDF to display units at the FSSs, the Gilmore Creek CDAS, and the San Juan WSFO.
- 2,400-hertz circuits from the Suitland computer to the Wallops Station, Va., CDAS to transmit WEFAX information.
- 2,400-hertz circuits from the Wallops Station CDAS to the Suitland computer for relay of GOES Data Collection System (DCS) information.
- 110-, 1,200-, 2,400-, 4,800- and 9,600-baud circuits for delivery of DCS information from the World Weather Building computer to a multitude of users. Computer-to-computer transmission is used in some cases.
- 7,200-hertz full-duplex computer-to-computer circuits for exchange of vertical profile radiometer data between Goddard Space Flight Center and Suitland.
- One 50-line and one 40-line multipoint voice coordination and conferencing networks connecting NESS operating facilities.
- Three 100 wpm multipoint teletypewriter circuits connecting various elements of SATCOM.
- A direct alternate voice, data facsimile circuit between Washington and Moscow for exchange of satellite information.
- Two 1.3308 Mbps simplex satellite circuits for the relay of TIROS-N data from the two CDA stations to Suitland, Md.
- Four alternate 9,600 bps/TTY-voice full-duplex satellite and terrestrial circuits between the two CDA stations and Suitland, Md., for the relay of real-time TIROS-N data and for transmitting command and control functions to the TIROS-N spacecraft. Also to provide alternate routing and backup for TIROS-N TTY and voice communications.
- Two full-duplex TTY-voice satellite and terrestrial circuits between the two CDA stations and Suitland, Md., for coordination of TIROS-N operations.
- One simplex C-5 conditioned data facsimile circuit between the Wallops CDA station and Suitland, Md., for the relay of sectorized TIROS-N HRPT data.

Department of Defense Systems

Automated Weather Network—This network, operated and maintained by the Air Force, is the backbone of the military weather communications system. It consists of four real-time communications switching computers at Carswell AFB, Tex., RAF Croughton, England, Fuchu Air Station, Japan, and Clark Air Base, Philippine Islands, linked by high-speed data circuits. The overseas automatic digital weather switches collect data from radio intercept sites and low-speed feeder circuits. These data are transmitted at 3,000 wpm to the continental U.S. switch at Carswell AFB where the information is examined, sorted, edited, compiled into specific weather messages, and switched to military and civil customers. Besides low-speed distribution to Department of Defense weather units, data are transmitted by high-speed circuits to the Air Force Global Weather Central, Navy Fleet Numerical Weather Central, NMC, and the WMSC at Kansas City. All circuits are full-duplex, permitting a total exchange of data that includes reports from field units to military and civil processing centers and products from these centers to the field units.

Continental United States Meteorological Data System (COMEDS)—The COMEDS network is the primary communications system for collecting, editing, and disseminating environmental data at military locations within the United States. COMEDS consists of 19 regional circuits in the United States and 1 regional circuit for Hawaii. These regional circuits are full-duplex and operate at 1,200 words per minute; each circuit has about 25 terminals. In addition, USAF has integrated the weather data requirements of North American Air Defense/Aerospace Defense Command into COMEDS. The Air Defense Tactical Weather Circuit Network was eliminated as a result of this action.

Naval Environmental Data Newtork—This network provides for high speed dissemination of unique meteorological and oceanographic computer products from FNWC at Monterey to specially equipped locations in the United States and overseas. The network provides for rapid collecting, processing, disseminating, and displaying of environmental data and consists of on-line telecommunications equipment, automated display devices, digital computers, and associated circuitry.

Facsimile Networks

Facsimile networks and broadcasts are designed to transmit graphical weather information from selected centers to civil and military weather offices and users. The Department of Commerce is responsible for the basic facsimile circuits, including those that fulfill international commitments. The Department of Defense has responsibility for those circuits filling unique military requirements.

Air Force Global Weather Central also provides backup to the NWS National Facsimile and National Aviation Meteorological Facsimile networks in emergencies as outlined in the *Federal Plans for Cooperative Backup Among Operational Processing Centers,* December 1976, FCM 76-4.

Department of Commerce

The various internal and external networks listed below were established to serve different users and different geographical areas, and include both longline and radio systems.

National Facsimile (NAFAX) Network—NAFAX is a long-line network used to distribute a comprehensive set of charts depicting analysis, forecast, and selected observational data to civil and military weather service offices and to a variety of other users. Basically a graphics network, NAFAX serves about 250 NWS offices, 450 military and civil governmental offices, and nearly 350 nongovernmental users—more than 1,000 drops in all.

With the exception of the radar summary charts prepared by the National Severe Storms Forecast Center and digitized cloud pictures prepared by NESS, all materials originate at NMC. The network extends throughout the United States.

National Aviation Meteorological Facsimile (NAMFAX) Network—NAMFAX is a long-line network designed to provide selected civil and military weather offices with graphic guidance materials including satellite products in support of international high-altitude aviation operations. The network operates at 120 and 240 scans per minute with automatic selection of speed and mode depending on the type of product being transmitted. The network extends to the U.S. borders, and carries products to Alaska for relay to the Intra-Alaska facsimile network. The network is also extended to Canada, Curacao, Mexico, Nassau, and San Juan.

Forecast Office Facsimile (FOFAX) System—FOFAX is a long-line network designed to distribute NMC forecast guidance materials and NESS satellite products to the WSFOs. It also is used to distribute NESS-prepared geostationary satellite photographs and digital mosaics prepared from NOAA polar-orbiting satellite data. FOFAX operates at 120 and 240 scans per minute and has automatic selection of speed and mode.

Tropical Regional Analysis Facsimile Circuit (TROPRAN)—TROPRAN is a long-line network used to distribute tropical area analyses and prognoses. It carries NMC products for use by the National Hurricane Center and provides NESS tropical area satellite data for all users on the circuit. It also carries charts manually prepared by NHC to NMC for relay to the Caribbean HF radio broadcast from Brentwood, N.Y., and to FOFAX.

Intra-Alaska Facsimile Network—This network is a system of microwave, troposcatter, satellite links, cable, and high-frequency radio facilities used to distribute graphic materials throughout Alaska. Besides the charts prepared by WSFO Anchorage, charts received from NMC are switched automatically into the network. At present the Intra-Alaska Facsimile Network serves 13 Department of Defense, 11 NOAA, 3 FAA, and 1 Coast Guard offices, and private users. FAA and NOAA provide funds for that portion of the NAMFAX circuit to Alaska by means of a satellite channel from Valley Forge, Pa., to Talkeetna, Alaska. NOAA provides about 90 percent of the funds for circuitry within Alaska; the Department of Defense funds the rest. Parts of the backside of the intra-Alaska facsimile network are used to deliver tsunami and tide gage information to the Palmer Observatory in Alaska.

Department of Defense

Strategic Facsimile Network—The Strategic Facsimile Network is a landline and microwave net that extends to selected Department of Defense users at about 70 locations in the United States. AFGWC at Offutt AFB serves as the transmitting facility. The Strategic Facsimile Network supplements the facsimile systems of the Department of Commerce by providing specialized graphical data oriented to

military operations. It is used primarily to support the readiness of U.S. strategic weapons forces and secondarily to support airlift and tactical forces. The network operates at 120 or 240 scans per minute. Most products are computer generated and transmitted into the network by a minicomputer.

Overseas Facsimile Networks—To satisfy the needs of military customers overseas, AFGWC at Offutt AFB transmits specialized products to locations in Europe over the European Facsimile Network (EURFAX) and to the Pacific over the Pacific Facsimile Network (PACFAX). Both networks are programmed to operate at 120 to 240 scans per minute when testing and circuit upgrading is complete. The program to upgrade the EURFAX system with DL19W facsimile equipment was completed during December 1977. Most products are generated by AFGWC; however, a limited number of specialized products are placed on the circuits in-theater. Manually prepared products and German indigenous products, as required, are placed in the EURFAX schedule by the Forecast Unit at Capaun Air Station, Germany. Some Japanese indigenous products are entered into PACFAX at Yokota Air Base, Japan.

Fleet Weather Broadcasts—The Naval Communications System supports the Naval Weather Service in its requirements for specialized operational communications. Meteorological traffic is handled in the same manner as other Navy traffic; no center or unit is dedicated exclusively to meteorological communications. Meteorological information is transmitted to operating forces of the Navy by means of radio (continuous wave, teletypewriter, and facsimile) broadcasts. Designated Fleet Weather Centrals are responsible for contents of these broadcasts, which include observations, analyses, forecasts, and warnings. In preparing broadcasts, the centrals and facilities make use of not only their own specialized products and those from FNWC, but also—to the extent possible—products from the Basic Meteorological Service and data from Department of Defense's Automated Weather Network.

Other Facsimile Broadcasts

International radio facsimile meteorological broadcasts are transmitted by means of leased commercial high-frequency (HF) radio transmitter facilities. These broadcasts are beamed primarily toward the Caribbean, Central America, South America, and southwest Pacific areas.

Several facsimile broadcasts are relayed through the NASA satellites ATS 1 and 3, as well as the SMS/GOES systems.

Marine HF radio facsimile meteorological broadcasts are transmitted from the U.S. west coast by means of Coast Guard transmitter facilities and are intended primarily for reception by ships at sea. A special HF radio facsimile service is provided to the Pacific coast and high-seas tuna fleet by a cooperative NOAA-Scripps Institute of Oceanography effort via Radio Station WWD at La Jolla, Calif.

Real-time reconstructed radar images consisting of weather echoes with added handwritten annotations and geographical overlay are transmitted in facsimile mode from WSR-57 radar sites equipped with transmitters. There are now 35 transmitter sites with this capability. The two operational modes being used are hard-wire private line circuits leased from common carriers and direct-distance dialing. Either of these services is available to interested government and non-government users on a cost-basis.

Publications

The Federal Coordinator for Meteorological Services and Supporting Research has either prepared or is preparing a series of publications covering the broad spectrum of meteorological programs in the Federal Government. Following is a list of these publications and their status:

The Federal Plan for Meteorological Services and Supporting Research (Published annually)

World Weather Program Plan (Published annually)

National East Coast Winter Storms Operations Plan (Revised annually)

National Hurricane Operations Plan (Revised annually)

National Severe Local Storms Operations Plan (Revised annually)

Federal Plans for Cooperative Backup Among Operational Processing Centers (December 1976)

Federal Plan for Meteorological Rocket Observations (September 1976)

Federal Computer Plan for Operational Forecasting and Atmospheric Modeling Research (August 1975)

Federal Plan for National Climate Services (February 1974)

National Plan for Rocketsonde Support for Special Events (February 1974)

Federal Plan for Weather Radars (November 1974) (Under Revision)

Comparison Test of Meteorological Measurements From Weather Reconnaissance Aircraft on May 28, 1971 (June 1973)

Federal Plan for Natural Disaster Warning and Preparedness (June 1973) First Supplement fiscal years 1976-1980 (June 1975)

Federal Plan for a National Agricultural Weather Service (January 1971) (Under revision)

Federal Plan for a National Fire-Weather Service (March 1967) (Under Revision)

Acronyms

ABDIS	Automated Service B Data Interchange System
ACPL	Atmospheric Cloud Physics Laboratory
AFB	Air Force Base
AFGL	Air Force Geophysics Laboratory
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services
ALWOS	Automated Low Cost Weather Observation System
ARTCC	Air Route Traffic Control Center
AV-AWOS	Aviation Automated Weather Observation System
AVHRR	Advanced Very High Resolution Radiometer
AWDS	Automated Weather Distribution System
AWP	Aviation Weather Processor
bps	bits per second
CB	Chemical-Biological
CCEA	Center for Climatic and Environmental Assessment
CDAS	Command and Data Acquisition Station
CDDF	Central Data Distribution Faciltiy
CEDDA	Center for Experiment Design and Data Analysis
COMEDS	Continental U.S. Meteorological Data System
CWSU	Center Weather Service Unit
DCPLS	Data Collection and Platform Location System
DCS	Data Collection System
DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DOE	Department of Energy
DOI	Department of Interior
DOT	Department of Transportation
EBS	Emergency Broadcast System
EDS	Environmental Data Service
EPA	Environmental Protection Agency
ERBSS	Earth Radiation Budget Satellite System
EURFAX	European Facsimile
FAA	Federal Aviation Administration
FAMAS	Field Artillery Meteorological Acquisition System
FGGE	First GARP Global Experiment
FM-CW	Frequency Modulated—Continuous Wave
FNWC	Fleet Numerical Weather Central
FOFAX	Forecast Office Facsimile
FSS	Flight Service Station
GARP	Global Atmospheric Research Program
GATE	GARP Atlantic Tropical Experiment
GMT	Greenwich Mean Time
GOES	Geostationary Operational Environmental Satellite
HF	High Frequency
HIRS/2	Modified High Resolution Infrared Sounder
HRPT	High Resolution Picture Transmission
IR	Infrared
ITOS	Improved Tiros Operational Satellite
LACIE	Large Area Crop Inventory Experiment
LANDSAT	NASA's earth resources technology satellite
MAWS	Modular Automated Weather System
MOS	Model Output Statistics
NAFAX	National Facsimile
NAMFAX	National Aviation Meteorological Facsimile
NASA	National Aeronautics and Space Administration
NDC	National Distribution Circuit
NEDS	Naval Environmental Display Station
NESS	National Environmental Satellite Service
NHC	National Hurricane Center
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NSSFC	National Severe Storms Forecast Center
NWP	Numerical Weather Prediction
NWS	National Weather Service
OLS	Operational Linescan Systems
PACFAX	Pacific Facsimile
RADAP	Radar Data Processing
RAWARC	Radar Report and Warning Coordination
SATCOM	NESS Satellite Communications System
SCAN	Surface Condition Analyzer
SEAS	Shipboard Environmental Data Acquisition System
SEASAT	NASA's research satellite dedicated to marine observations
SEM	Space Environment Monitor
SFSS	Satellite Field Services Station
SMS	Synchronous Meteorological Satellite
SR	Scanning Radiometer
TDL	Techniques Development Laboratory
TIROS	Television Infrared Observation Satellite
TOVS	TIROS N Operational Vertical Sounder
TROPRAN	Tropical Regional Analysis
TTY	Teletypewriter
USAF	United States Air Force
USDA	United States Department of Agriculture
VAS	VISSR Atmospheric Sounder
VHRR	Very High Resolution Radiometer
VISSR	Visible and Infrared Spin Scan Radiometer
VOR	Very High Frequency Omni Range
VTPR	Vertical Temperature Profile Radiometer
WEFAX	Weather Facsimile
WMO	World Meteorological Organization
WMSC	Weather Message Switching Center
wpm	words per minute
WSFO	Weather Service Forecast Office
WSO	Weather Service Office